

Lot 21



38753/B





THE
Religious Philosopher

William Ross

OR,
The Right USE of Contemplating the
WORKS
OF THE
CREATOR.

I. In the wonderful Structure of Animal Bodies, and in particular of Man.
II. In the wonderful and wise Formation of the Earth, and of the
various effects upon Animal and Vegetable Bodies.
III. In the astonishing Structure of the Heavens, with all its
Bodies, for the Constitution of Seasons and Years.

VOLUME THE SECOND.

Containing, which, all the late Discoveries in Natural History,
and Astronomy, together with the various Improvements made in
the Arts and Sciences, are fully and carefully treated of, by the Author.
Printed in the Year MDCCLXXV.

Continued from the Low Dutch.

To which is added a Letter to the Reader, by the Author.
Printed in the Year MDCCLXXV.

The Third Edition.

Adorned with CUTS.

LONDON,

Printed by J. Knapton, at the Sign of the Bible, in Pall-mall.
MDCCLXXV.

THE

OF THE

OF THE

OF THE

OF THE

VOLUME

Translated from the Low-Dutch

By J. T. DeJager, LL.D. F.R.S.

Third Edition

London

M DCC XXIV

THE

Religious Philosopher:

OR,

The Right USE of Contemplating the

WORKS

OF THE

CREATOR.

- I. In the wonderful Structure of Animal Bodies, and in particular MAN.
 II. In the no less wonderful and wise Formation of the ELEMENTS.
 and their various Effects upon Animal and Vegetable Bodies. And,
 III. In the most amazing Structure of the HEAVENS, with all its Furniture.

Design'd for the Conviction of Atheists and Infidels.

VOLUME the Second.

Throughout which, all the late Discoveries in *Anatomy, Philosophy,*
 and *Astronomy*, together with the various Experiments made use of
 to illustrate the same, are most copiously handled by that learned Ma-
 thematician Dr. NIEUWENTYT.

Translated from the LOW-DUTCH.

To which is prefix'd, a LETTER to the Translator by the Reverend
J. T. Desaguliers, LL. D. F. R. S.

THE THIRD EDITION.

Adorned with CUTS.

LONDON:

Printed for THO. LONGMAN, at the *Ship* and *Black Swan* in *Pater-noster-Row*,
 M. DCC. XXIV.



The Right Use of Contraception

WORKS

CRITICAL

DESIGNED FOR THE USE OF STUDENTS

THROUGHOUT THE COURSE OF STUDY

AND FOR THE USE OF THE TEACHER

IN THE TEACHING OF THE HISTORY

OF THE UNITED STATES

AND OF THE WORLD

IN THE TEACHING OF THE HISTORY



CONTEMPLATION XIX.

Of Water.

SECT. I. *Without Water every thing would dye with Thirst.*

NOW let the Philosopher that pretends still to doubt of all these most important Truths, pass on with us to the *Contemplation* of WATER; and without using any farther Preamble, we may venture to say, that he will at least agree with us, without the necessity of supporting this Truth by many Experiments, that in case there had been no such thing as Water in the World, he, and all Mankind, and most of the other Living Creatures, even in the midst of a Superfluity of Air, and other Food, would certainly perish in a very small compass of time; since Thirst, if it be not extinguished, is no less fatal than Hunger itself, and all Men and Beasts too, a few of the last only excepted, if there be any Truth in Experience, are unable to subsist without Drink.

SECT. II. *Convictions from thence.*

THIS being laid down, if it be by Chance that Water is found out, which itself is the only Drink, or at least the principal Ingredient of all other Drinks, it is likewise unquestionably by the same Chance that a Man, or any other Animal, lives a Year, or a much less time, after his Birth. And since the most obdurate Atheist must acknowledge that all Living Creatures whatever, are of such Structure, and have the Parts of their Bodies so disposed, in relation to Water, that they are able to take and use it themselves; that they are even excited thereto by Thirst when they want it; that they can only be refreshed by Water, whether they drink it Pure, or whether they make use of other Liquors, such as Wine, Beer, Cyder, and the like, of all which it is the Foundation; and that therefore, it would not be sufficient for them to have the use of all other Liquid Matters: Insomuch, that if the whole Sea, and all Rivers, were made of Spirits entirely separated from their Water, or of other Liquors, in which there were not a sufficient mixture of Water, they would still all perish with Thirst. Can it then be thought, that it is owing to mere Chance, that all Creatures have the Faculty of supporting their Lives by Water, and likewise that Water has by the same Chance acquired the Properties that are necessary for that Purpose?

SECT. III. *Without Water every living Creature would likewise dye of Hunger.*

To this we may likewise add, that without Water the Earth would not be render'd Fruitful, nor any Tree or Plant would be able to spring out of it;

So that the Condition of the World would be still very miserable, if all the Men and other Creatures in it, could subsist without Water; since every living thing would soon be deprived of its Meat as well as Drink; the Consequence of which would be certain Death.

SECT. IV. *Experiments proving that Plants consist for the most part of nothing but Water.*

LET no Body imagine that we go too far in extolling the Uses of Water: That famous Experiment of *Van Helmont* does plainly shew how much Water contributes to the Growth of every thing. He took two hundred Pounds Weight of Earth, first drying it thoroughly in an Oven, and then pouring Rain Water upon it, and having planted in it the Twig of a Willow, that weighed five Pounds, he found at the end of five Years, that the said Twig was grown to a Tree, weighing 169 Pounds three Ounces, without counting all the Leaves that had fallen in four Autumns; but that the said Earth being dried again as before, was scarce visibly diminished, or at most, had not lost above two Ounces of its Substance. And yet nothing more was done to it, then pouring upon it Distilled or Rain Water; for which Reason likewise, the Pot was cover'd with a thin Plate full of Holes, to prevent, as far as possible, either the Encrease or Diminution of the Earth by Winds, &c.

The like Experiments may be seen in Mr. *Boyle's Sceptical Chymist*, Part II. where without any Diminution of Earth in one Year, at least without any that was worth speaking of, you will read of a Pumkin of a very great Weight, which was produced only with Spring or Rain Water.

The same Author does likewise mention other Experiments made upon little Plants of *Mint*, *Sweet-Marjoram*, *Purslain*, &c. which I have often repeated with Pleasure and Wonder, by putting them into little Glass Phials, where I could observe them spreading out their Roots, putting forth their Leaves, and becoming Larger and Longer: The said Mr. *Boyle* says, that having distilled them in a little Retort, tho' they were produced by nothing but Water, yet like other Plants of the same kind, that spring from the Earth, they yielded a little Water, a stinking Spirit, and an Oil, the Remainder being nothing but a *Caput Mortuum*, or dead Coal.

How many Trees grow in *Norway* (as Travellers that have been there relate) in Places where there is very little Earth, and hardly any thing besides barren Rocks? Whence comes all that Wood (which no Body will easily ascribe to the Rocks themselves) but from the Rain Water with which they are moisten'd? A like Instance occurs to me whilst I am writing this, of an Elder Tree, which sprang out of a little Cavity between two Stones of a Wall from whence the Mortar was fallen, and which in the space of two or three Months, from a little Plant, as it appeared at first, shot out several Branches longer than a Man's Arm; and yet, when it was pulled up, in order to discover the Communication between its Roots and the Earth, none could be found. Now, whether this was occasioned by the Seed of neighbouring Elder-Trees, brought by the Wind, and dropt into this Cavity, I shall not determine; it is sufficient for my Purpose, that it grew thus without any Appearance of Earth.

From

From whence have all those juicy Fruits, as Grapes, Cherries, Goosberries, Currants, and a thousand others, their agreeable Liquors, if it were not from Water; which by the Concurrence of other Particles, acquires so many various Tastes, and, as we have hinted above, produces so many pleasant Drinks and Wines.

That this is true, the Chymists know full well, who by distilling not only these juicy Substances, but likewise all other Plants, from the hardest Woods of Trees to the meanest Shrubs (to say nothing here of all the Parts of Animals that are nourish'd by those Plants) even from Horns, Bones, Ivory, and other Matters, without the addition of any Liquid; do plainly shew by the Liquors coming out of them, and which the most ignorant Person cannot suspect to be in them, how great a share Water has in the Composition of the aforesaid Things.

To pass by here what some famous Chymists themselves have pretended, that the Foundation even of Metals and Minerals is Water only; which therefore, (if one may believe 'em,) as well as Living Creatures and Plants, may be reduced to an Equilibrating Water, by the help of their Renowned *Alchemist*. But we don't insist upon this, because if for many Reasons it is not to be judged uncertain, yet it is still very dark and obscure. However, this is at least an undoubted Truth, that neither Plants, and consequently neither Man nor Beast, that uses the same for Food, can be preserv'd without Water, and that all Food does for the most part consist of Water.

SECT. V. *We do not here enquire, whether Water be a Simple or Compound Body.*

I Do not here dispute, whether Water is to be consider'd as a simple Substance, the Parts of which are all of the same Figure; and which, as it happens in Ice and Snow, joining themselves together, may compose the solid Bodies of Plants; or, whether it is to be affirmed, that Water is a mixed Fluid, in which all sorts of Particles, proper for the Composition of Plants, are to be found, which, after the Evaporation of their Waters, remain in the Plants, and contribute to the Augmentation of their Size and Weight, as has been attempted to be proved by *Dr. Woodward, Phil. Transactions, Num. 253*. This is certain, that hitherto it could never be deduced from Philosophical Hypotheses, how it is possible, that Spirits, Salts, Oils, Earth and Ashes, &c. as has been shewn in the foregoing Experiments of *Van Helmont* and *Boyle*, should proceed from the same Water; and which is more, how Water can be proper, by producing so many various Smells, Tastes, and other Qualities in such various Kinds of Plants, to cause each of 'em nevertheless to grow up regularly and orderly, according to its own Nature.

SECT. VI. *Convictions from the foregoing Observations.*

It is necessary to shew more fully in this Place, how far the Wisdom of our adorable Creator and Preserver exceeds the Comprehension of the greatest Philosophers, who unless irrefragable Experience had taught them all this, could never have believed, nor ever have imagined that this could have been proved from their assumed Principles. If the Parts of Water, or those

that are mingled with Water, are formed by Chance only, are moved by Chance, and preserv'd by the same; since Chance works without any Rule, how could the growth of Plants, that has come to pass in so exact an Order in innumerable Places, so many Ages, with so much Advantage to those that inhabit the Earth, ever be expected, or ever be hoped for again in following Times, if every Thing were not directed and guided by an over-ruling Providence? I know very well what is usually affirmed upon this Occasion, by some, about the Figures of *Pores* in the Plants themselves; by others, about *Fermentation*; and by others again, about a *Panspermia*, or a Disposition of the Water, containing in itself the Seeds of all Things. But it would not be difficult to shew here, that all these Hypotheses, and such lofty Names, in which there is so little of Truth, are much too weak in any manner to make manifest the Ways of GOD in these Matters. And in case any one thinks he can deduce these Things, of which he is entirely ignorant (as he certainly is, of the manner how Water operates in all such Cases) from a natural and unknown Necessity, one need not prove any farther that he speaks without Foundation, since there can be no Demonstration of a thing that is entirely unknown.

SECT. VII. *An Experiment to shew that Water is changed into Earth.*

To shew this, it is known that the Evaporation or Exhalation of Water, as also the Distillation thereof, is a continual Work performed in Nature without ceasing; at least, in Rivers and Seas, where the Heat of the Sun is of any force; which causes the Matter to ascend in Vapours, and afterwards lets it fall again in the form of Mists, Dews, and Rains, and the like; after the same manner as the Chymists are wont to produce Evaporations and Distillations with the help of Fires.

Now that Water is hereby changed into Earth, has been experimentally shewn by Mr. Boyle; of which Sir Isaac Newton taking notice in his Book of *Opticks*, p. 319. uses these Words; *Water, by repeated Distillations, is turned into a solid Earth, as Mr. Boyle has discovered by Experiments*: Which is likewise confirmed by that diligent Enquirer, Robert Hook, and others, as may be seen in the *Philosophical Transactions*; saying, That all Waters, by frequent Distillations, are changed into a whitish and insipid Matter, which cannot be dissolved in Water again.

SECT. VIII. *Other Experiments relating thereto.*

As wonderful as this may likewise appear to some, it may, however, be proved by this Experiment, which gives us the entire Certainty thereof.

I. Because as often as we distil Water it always leaves some Earth behind it, which may render what has been said before probable to such as will not have the Patience to repeat those Distillations so many times after one another.

II. It may likewise be inferred from hence, forasmuch as every one knows that the Plants which have been already proved capable of being produced by Water only, are subject to Putrefaction, and are finally changed certainly for the most part into Earth.

III. This seems likewise to be plain, because the said Mr. Hook says in the before-cited place, that Sea-Water, tho' cleared as much as possible from all its Sand, yet being evaporated, does still leave some behind it.

An extraordinary Account whereof was communicated to the Royal Society in England, by Dr. Robert Plott, made upon the Salt-works in Staffordshire, which may be seen in *Philosoph. Transactions*, Numb. 145. where one Mr. Collins, writing about the same, says, That the great quantity of Sand proceeding from all Pickles, whether it be from the Salts of the Springs of the Sea, or from those that are dissolved in Common Water, was found to arise only from the boiling, before which there was none observed to be contained in those Liquors: Forasmuch as after having been filtrated or strained through an eight-double Holland Cloth, they did not leave behind them the least Marks of Sand. Which Experiment, at the request of the said Dr. Plott, having been again repeated with great Exactness, occasion'd some farther Speculation, as may be seen in the said Account.

IV. Now that Water may likewise be turned into a solid Body by Art, is plain from the *Sal Mirabile* of Glauber, which, according to his Assertion, will congeal all Liquids. And I have found Rose-water changed thereby into such a hard and petrified Matter, that being shaken about the Bottle which contained it, it burst one of the sides thereof. I have not made the Experiment upon other Liquids, having no more of the said Salt by me; and a new Preparation of it required a little too much Attendance, to meet with the exact Degree, whereby the Salt might be reduced to Powder without dissolving, which is however necessary in this Case.

I shall here add one Instance more, that occur'd to my late Brother; who having distill'd a Horse's Hoof, and first separated, by Sublimation, all the Volatile Salt from the Liquid Matter, which the Chymists call the Spirit, was just about throwing away the Remainder that smell'd strongly of Fire, and in which he could discover no sign of any more Volatile Salt; but however, to satisfy his Curiosity about the said Liquid, he thought fit to Distil it over again in Oven-Ashes, filling the whole Still with Ashes; and putting Fire under it, it yielded a very clear Liquor, which as long as the Joints were stoppt, was as fluid as Water; but upon pouring it from the Recipient into a round and thick Pint Bottle, he found, that as soon as ever it was in it, it was changed into a white, solid, and hard Substance, like Marble, without the least Appearance of any Moisture or Fluidity in it; and this solid Body assumed the perfect Figure of the Glass before it, just as melted Lead is used to do of the Mold in which it is cast: having viewed it many times with Amazement afterwards, whilst it retained the same Figure and Condition for several Months, at last, and by little and little (the Bottle not having been well stoppt) it returned again to a liquid Substance, of a Smell exactly like, if not exceeding, the strongest Spirit of Hartshorn or Sal Armoniac.

I thought fit to give an Account of this Matter here (since the Chymists hold that this Liquor, when all the Volatile Salt is as far as possible separated from it, to be nothing but a mere *Phlegm*, or Water, containing perhaps a few

a few Oleaginous Particles in it) to the end, that I might shew how little Knowledge the greatest Enquirers have yet attained to, of the internal Structure and Disposition of that which they call (and justly too, according to all appearance) Water: And after how many Ways it may be proved, that the Water of which we are now speaking, is capable of being converted into solid Bodies; to say nothing here about Ice, which when dissolved, is turned to Water again, and therefore does not seem to have undergone any real Change.

SECT. IX. *That living Creatures, Plants, Minerals, and even Metals themselves are produced from Water, shewn Experimentally.*

I RECOMMEND it to the Over-weaning Naturalists, to prove how it may be consistent with their Hypotheses:

I. That from Water not only Plants, and from them, when treated after a Chymical manner, Spirits, Oils, Salts, and a Terrestrial Substance or Ashes are produced, but,

II. Living Creatures themselves are likewise beholden to Water, if not altogether, yet in a great Measure, for the Substance of which they consist. This is plain, because they are nourished by Plants and Water; and the Distillation of all solid and fluid Parts of their Bodies, even of the very hardest, such as their Bones, Horns, and Teeth (as has been said before) experimentally shews, that Water is a great Ingredient thereof.

III. That besides Plants and Animals, even Minerals and Metals proceed from Water. Thus we see in the aforemention'd Experiments, that Earth proceeds from it; which is likewise reckon'd among Minerals: And particularly by the Experiments related in the *History of the Royal Academy of Sciences in France, for the Year 1702*, that from the Ashes of Plants (which have been shewn above to grow out of Water) Iron can always be extracted by the Loadstone. How all these things come to pass, has not yet been rightly proved by any one that I know of; but this plainly follows from thence, that our Knowledge of the real Essence of Things does not extend itself very far; and that the most haughty and strongest Mind must be forced to acknowledge here, that there does daily appear in Nature a Manner in which Plants and Animals are what they are, and according to which, Water does likewise operate; which is impossible to be deduced from any of their Hypotheses or Principles.

I beseech them therefore once again to consider with themselves, whether they have any cause to lean so much upon their own Understanding, which has not hitherto been able to teach them how a Plant grows, and of what it consists, and what Uses so common a Matter as Water, which has been examined and enquired into after infinitely different Ways, has in the World; and therefore, whether they can think that they judge wisely, that this their Understanding does not only instruct them of the Nature and Disposition of that Universe, containing all these particular Matters that are unknown to them, but moreover, that it is capable to determine whether the said Universe were Eternal, and how it subsisted from all Eternity, or whether it had
a Be-

a Beginning; in which they act just as wisely, as he that pretends perfectly to understand the whole Structure of a Watch, and yet is forced to confess, that he is ignorant how the least Wheel thereof is made. However, the Labour that is bestowed in the Contemplation of WATER (as much of it as there remains still unknown) will be abundantly compensated, if it only serves to convince Philosophers of the Weakness of their Understanding; whose great Presumption is oftentimes the only Stumbling-Block over which so many have fallen:

SECT. X. *The Ascent of the Water into the Air.*

BUT to go on to something else:

Could any Body, that had never seen it, believe that this Water, which, on account of its greater Weight than the Air, is seen to descend in Rain, Dew, Snow, and other Forms, can be made to ascend into the Air, and there to form the Clouds? 'Tis true, that as in many other Matters, so likewise in this, the Custom of seeing a thing frequently happen, makes it seem to be the less strange or wonderful; but it must however be confessed, that this is justly reckon'd among the Wonders of the Almighty in many Parts of the Sacred Writings; as in *Psal. cxxxv. 7. Jer. x. 13. and li. 16. He causeth the Vapours to ascend from the Ends of the Earth; he maketh Lightnings for the Rain: He bringeth the Winds out of his Treasures.* If ever he took the trouble to consider the various Opinions of the greatest Naturalists thereupon, we need only read what Mr. Mariotte, *Mouvement des Eaux, Part 2. Discourse 3.* and Dr. Halley, *Philosoph. Transactions, Numb. 183.* have said upon this Subject, to convince us that the Cause of this Ascent of Vapours is not so easy to be discover'd as some have imagined.

SECT. XI. *How such an Ascent happens.*

I SHALL not here enquire, whether this Opinion of Mr. Mariotte in this Matter be the most probable, namely, that there are little higher Cavities or Holes in the Air, thro' which the smallest Particles of Water being raised upwards, perhaps by the Pressure of the lateral Air, may pass, but at which the biggest are stopt; Nor, whether we may more rightly suppose with Dr. Halley, that a little Particle of Water may be so far rarified and blown up as a Bladder, by a warm Matter, that its Diameter, in Breadth, Length, and Thickness, may be ten times as large as it was before; in which Case this Particle may fill a Space a thousand times bigger than the former; retaining nevertheless the Weight only of one Particle of Water, which had been found to be but eight hundred or nine hundred times as heavy as just so much Air in Magnitude; and therefore, according to the Laws of Hydrostaticks, as long as it remained thus rarified, it would continue ascending in the Air, exactly after the same manner as a solid piece of Glass, which in such a Condition would sink down into the Water, may be blown up into a round Bubble, and thereby with the same Weight, occupying more Place in the Water, would ascend and float upon it.

I leave

I leave the Arguments of these great Men to their own Weight; but forasmuch as the Authors of them acknowledge, that they believe that there may be other Ways by which the Ascent of Water, which is heavier, into the Air which is lighter, may be explain'd; the following (which I therefore take the liberty to propose here) seems likewise to be one of those; the rather, because it is not so much founded upon an Hypothesis, as upon Experience.

SECT. XII. *Experiments shew that Air does likewise adhere to other Matters.*

To shew the same, it is known:

I. That Fire is lighter than Air: This wants no farther Proof, forasmuch as we see with how great Velocity all Flames ascend into the Air.

II. That lighter Matters can stick and fasten themselves to heavier: This appears in most Liquids, which adhere and hang upon other Matters heavier than themselves.

Accordingly we see that the Air (which, tho' fluid, yet very moist) does cleave to many other Substances. To prove this, we need only throw a few rusty Nails into a Glass of clear Water; and if you view them sidewise, you will see many little Air-Bubbles cleaving to them.

And to the end that it may not be thought that this adhering Air proceeds from the Water itself, I find by my Notes of the 21st *January*, 1696, that some little pieces of rusty Iron and Brass were thrown into Lye, in which there is no Air, and presently some Bubbles appeared upon them; and upon exhausting the external Air, which gravitated upon them, the said Bubbles became larger, and by their Expansion, shewed themselves to be Air; and this appear'd the plainer, because if one rubbed off with the Finger those Air-Bubbles that remained upon the Iron whilst it was under the Lye, one saw, that how much so ever the incumbent Air was drawn off with the Pump, there did not appear one new Bubble: so that it is plain from hence, that the Air will cleave to solid Bodies, and even to Metals themselves, which perhaps may also be the Cause of Rusting.

Now that Air does likewise adhere and mix itself with Water, is sufficiently known to those that have ever seen what a Quantity of Air-Bubbles appear when the Pressure of the Air is removed by the Pump from off the Water.

SECT. XIII. *Experiments to shew that Fire will cleave to solid Bodies.*

III. Now as Air, so likewise can Fire cleave to heavier and solid Bodies. This appears from Flint-stones, and other Bodies, not easily reducible to Fluidity when they are made red hot. For that the Heat thereof is to be attributed to the adhering Fire-Particles, and not, as some Philosophers think, to the swift Motion of the small and fine Parts, whereof these and other Bodies are composed, appears from hence, that in case the Parts of the Flint itself should be put in such a violent Motion, it would lose its Solidity, and be dissolved.

But for a farther Certainty of the Matter, one need only read what Mr. Boyle says in his Book *de Ponderabil. part. Flammæ*, upon several Experiments there recited, where he shews, that even Copper, Tin, Steel, Silver, Pewter, burnt Hartshorn,

Hartshorn, Chalk and Coral, become heavier by the Particles of Fire that cleave to them. And to know that this Encrease of the Weight, did not so much proceed from the Parts of other gross Bodies mingled with the Fire, as from those of the Fire itself; one may see there that some of those Bodies being wholly shut up in Glass, became heavier only by the pure Flames of Brimstone, or of Spirit of Wine; which could not happen otherwise than from the small Fire-Particles that must first have penetrated the narrow Pores of the Glass. [See the said *Boyle de Penetrabilitate Vitri à ponder. part. Flam.*]

SECT. XIV. *Fire will likewise cleave to Water; proved by Experiments.*

IV. NOW that Fire can likewise join in itself to Water, may be shewn by setting a Glass, or rather a little Tea-Cup (to prevent the breaking of it) full of very hot Water under the Receiver of an Air-Pump; when you will often see at the very first Exhaustion, if the Water be hot enough, or at least at the second or third, so great a Motion in the Water, that, like boiling Water, it will run over the Brims of the Vessel. This Experiment may be very easily made by all that use Air-Pumps.

When we tried this upon the 24. of *December*, 1705, there was a little Glass full of cold Water put under the Receiver at the same time, which, according to Custom, did indeed disclose a few Bladders or Air-Bubbles, but no kind of Motion that was any ways comparable to that of hot Water; so that this last Motion seems to be more properly owing to the Fire than to the Water.

But to be assured thereof, and to satisfy the Objection, whether the Heat of the Air might not likewise be the Cause of this more violent Motion in the hot Water, on the 21st of *January*, 1706, we heated some Lye, in which there is no Air, and put it into a little Glass under the Receiver; and to prevent the Pump from being spoiled, if it should chance to run over, we put the first Glass into a second: And we observ'd upon the second Turn of the Pump (tho' there was no Alteration at the first) that the Lye, with a sudden bursting, flew out above both the Glasses; which can only be ascribed to the Particles of Fire contained in it; forasmuch as no Air ever mingles itself with this kind of Liquor.

Afterwards, upon the 7th of *June*, 1709, making the same Experiment again with Water, we filled two equal Tea-Cups at the same time with boiling Water; and putting one of them under the Receiver, we found that the Receiver itself, upon taking off the Pressure of the Air, and during the Motion of the Water, was very hot at the Top. Now, whether this proceeded from hence, that the Fire-Particles being freed from the Pressure of the Air, and extricating themselves by their Motion from the Water, rising up to the Top, and passing thro' the Glass, render'd it hotter there than in any other Place, or whether it be only to be ascribed to the Vapours, we shall not here dispute; but this is true, that the Water, which had undergone so many Motions in the Receiver, being taken out from thence, was much colder even to the Touch of all that were then present, than that which was

never put under it : Whereas, if it be supposed, that the Heat were caused alone by a greater Motion of the Parts of the Liquor, and not singly by those of the Fire, the Water that had been under the Receiver, and had been put into such violent Motion, should have been much hotter than that which had suffer'd none.

And thus it seems to appear from hence, that the Water under the Receiver had therefore lost more of its Heat than the other, because the Fire-Particles, by taking away the Pressure of the Air, got an Opportunity of freeing themselves by their own Motion from the Water, from whence, being flown out, the Water remained less warm than that other, in which the Pressure of the Air had hinder'd the Fire-Particles from separating themselves so suddenly from the Water.

Now whether this Adhesion of the Particles of Fire to Water may likewise be supposed to contribute something, and to be the Cause either alone or jointly, of that Property of the Water whereby it extinguishes the Fire, I shall not examine any farther here ; forasmuch as the giving a true Reason of such Extinction, as common, and therefore as unheeded as it may appear to many, does (if I may speak my Mind freely in the Matter) require a great deal of Consideration.

SECT. XV. *Three Consequences from the last Experiment.*

To proceed ; I have noted three Things, that seem to follow from the abovemention'd Experiment.

First, That as Water and Air are particular Substances, it seems that we might conclude from hence, that Fire also should be esteemed as such ; and not be look'd upon, consider'd as only a swifter Motion of the Parts of all other Bodies. This may be inferr'd from the Water's becoming colder, after it has been just put into Motion, as has been shewn, therefore need not be here repeated. It likewise seems to appear from hence, that cold and hot Water, being at the same time put under the Receiver, and the Pressure of the Air remov'd, the hot Water, immediately after its great Motion, did not shew the least moving Particles, whereas there were several Stirrings observed in the cold, by the Rarefaction of Air, a good while after. Now 'tis known, that by Boiling and Heat, the Air flies out of the Water, so that these Risings and Ebullitions seem not to be imputable to any other Cause than to the Fire-Particles that succeed and cleave to the Water, and which, by flying away, leave the Water at rest.

Secondly, From hence it likewise seems to appear, that the Fire-Particles are very Elastical and Expansive : Forasmuch as we see, that by removing only the Pressure of the Air that keeps them down, they exert their Motion of their own accord, which is also a Property of an Elastick Body.

Thirdly, The last thing that may be inferr'd from this Experiment, and may likewise be of use, is, that the Fire which sticks close to the Water, as soon as it comes into an Air which is thinner and less powerful in its Pressure, abandons the Water and flies away from it.

SECT. XVI. *Water and Fire seem to produce a Composition lighter than Air.*

FROM all this it is to be observed, that Fire and Water being united and mingled together, may make a Composition lighter than so much Air, and which can ascend in it; just as Iron and Cork being fasten'd together, will float upon the Water, tho' the Iron be heavier than the said Water. I remember to have seen an Experiment very analogous to this, by throwing a Clod or Lump of unrefined Brimstone, and letting it sink in Lye, to discover whether it contained as much Air in it as Salt-petre, in which we found a great deal; but having taken off the Pressure of the impendent Air, we did not only see some little Bubbles swelling up, but what is chiefly remarkable here, some of the little Bits of Brimstone that were broken off, were driven upwards by these Bubbles, and when they burst, the Brimstone sunk down again. I have observed the same when Water was thrown into Salt, and the Pressure of the Air removed. From whence may be inferr'd, that a lighter fluid Matter may joyn itself to a heavier, and make one Compound therewith, and ascend and float in a Liquor, in which the heavier, being alone, would sink. Thus Experience likewise teaches us, that a small Heat, and consequently a little Fire, can make Water evaporate and rise upwards, even without boiling; And so we also see all volatile Salt, such as those of Sal-Armoniac, of Hartshorn, &c. ascending by the Warmth of a Fire that is hardly sensible. The same does happen too in pure burning Spirits, and in all other things that are esteemed the most volatile by the Chymists.

And if this Adhesion of the Particles of Fire to these Matters, be not the only Cause thereof, it may at least be supposed from what has been said before, that it may be reckon'd a concurrent Cause: And it even seems to be more credible, that this Cause is more common than that by which the Water, before it is capable of turning itself into Vapours, must be rarified into a nine or ten times greater height, length and breadth: Which is no ways, at least very rarely, experienced in Substances that evaporate with so small a Heat; and in others, such as Volatile Salts, can hardly be supposed to happen.

SECT. XVII. *Water must be divided into exceeding small Particles, in order to be evaporated.*

THE last thing that is required above all the rest, as being the chiefest Occasion of the Rising of the Water into the Air, is, that it should be divided into exceeding small Particles; that it may be so much sooner enabled, in Conjunction with Fire, to make a compound Body lighter than so much Air. Thus we see in all Distillations, that there do not ascend great and entire Drops, but only very fine and small Particles. The same is plain in all Chymical Sublimations; as likewise in the Smoak of Fires made of Coal, Wood, Turf and the like, which being divided into very minute Parts, are carried up into the Air by the adhering Fire: But being collected into a greater Body, when they are turned into Soot, they become so heavy, that

they will not ascend, till they be reduced by other Distillations, for Instance, to Bodies of a much smaller size.

SECT. XVIII. *Vapours ascend both by Heat and Cold.*

BUT to make an end of this Enquiry ; whatever may be the Cause of the Ascent of watry Vapours, this is certain, that Water being heated, either by the Sun, or by our common Fires, tho' in itself it is so much heavier than Air, yet it will be carried up into it.

Now, whether we are likewise to suppose that there are particular Particles which produce Cold, as Fire does Heat, and which cleaving to the Water, make up a Body lighter than Water itself, and so cause it to ascend in Vapours, we shall not here dispute ; this is certain, that we see Vapours ascending from the low Grounds in the coldest Weather, and when the Water is frozen hard, and that even Ice and Snow are lighter than the Water of which they are composed, and consequently must evaporate : But of this hereafter.

SECT. XIX. *The Laws of Hydrostatics*

TO proceed ; it is well known to such as understand the Laws of Hydrostatics, that,

I. If a Body is to be carried upwards in any Liquor, an equal Bulk of the said Liquor must gravitate or weigh more than such a Body.

II. That in order to cause a Body to sink in a Liquor, an equal Bulk of the said Liquor must weigh less than the Body.

III. If you would have the Body neither to rise nor fall, but preserve its Place in any Part of the Liquor, an equal Quantity of the said Liquor must weigh equally with the Body, which may be easily proved by Experiments.

SECT. XX, and XXI. *The Vapours in the Air adapt themselves to these Hydrostatical Laws ; as appears by several Experiments.*

NOW if we suppose that *Tab. XV. Fig. 1.* represents the Globe of the Earth, *W P Q R S*, surrounded by the Air as far as *B A D* ; which being heavy in itself, and thereby capable of being compress'd, grows continually finer from below at *P*, upwards thro' *g*, and *F* to *B*, and consequently lighter ; because its Elastick Faculty dilates it more in proportion as the Pressure of the superiour Air is diminished, and, as it scatters the Parts of the Air from each other, renders it lighter in an equally large Space. And if we now suppose farther, that this same Air is heavier below at that Part of the Globe that lies between *F* and *P*, and lighter above between *F* and *B*, than the Water evaporated or mingled with Fire ; so that about *F G H*, the said Air is of equal Gravity with it, it will follow from what has been just now mention'd, that the Vapours between *F* and *P* will ascend ; that being raised to the Bounds of the Equilibrium *F G H*, they will float like Clouds at *F* and *I G* ; and being æquipois'd, will neither rise nor fall ; but when raised higher, to *B F*, or *H D*, they will descend.

This

This will happen much after the same manner, as when you pour Quicksilver and Water into a Glass, and then throw in a piece of Iron, which will sink down into the Water, but float in the Quicksilver, till it arrive at the place between both of 'em, where it can meet with its Equilibrium, and there it will remain between the two Fluids, the uppermost of which, Bulk for Bulk, is lighter, and the lowermost heavier.

We must not imagine that these Notions of the Air are supported only by mere Hypothesis: *First*, Because it has been experimentally proved above, that the Air is of such a Property, that when it is pressed by any Weight, the Parts of it are squeez'd closely together, and so taking up a smaller Space, the same Quantity becomes heavier. So that it having been proved before in *Contemplation XVII. §. XX.* by a Tube IF, (*Tab. XIV. Fig. 1.*) filled with Quicksilver, that the same Air, which without Compression is above of the bigness of F, when squeez'd closer by the Weight of the Quicksilver, will lie in so much a smaller Space below at I, and consequently becomes heavier in proportion to its Bigness; so that, for instance, if we suppose that F above, is ten times as large as I below, a Cubical Inch of Air will press or weigh ten times as heavy at I as at F; since, by the Compression below, there is ten times the Quantity of Air contained in the same Space I, as above at F.

And, *Secondly*, which may serve for an Experimental Proof, because such as have climb'd those high Mountains, find it to be true, you may see, among many others, a remarkable Account thereof in *Varenius, Geograph. Gener. Lib. I. cap. 19. §. 41.* Where somebody that climb'd up one of the *Carpathian Mountains in Hungary*, which are much higher than those of the *Alps*, saw the white Clouds floating in the Air below him, some of which were however higher than others, according as the Matter whereof they were composed, being lighter or heavier, determined their Equilibrium higher or lower; for that numerous Particles, and consequently of different Weight, are raised up into the Air, under the Denomination of Watry-Vapours, or other Exhalations, has been shewed above in our Discourse upon METEORS: The said Person did likewise observe the Air in which he was, to be so calm and serene, that it did not produce Wind enough to move the least Hair of his Head; notwithstanding that he had been sensible of a strong Wind in the lower Parts of that Mountain. But that which seemed to be the clearest Proof of a greater Thinness of Air, was, that in discharging a Musket, at the very Top of the Mountain, the Report or Sound of it was no louder than that which is produced by the breaking of a little Stick. Now how much the Rarefaction, or Thinness, of the Air contributes to the Diminution of Sound, appears by hanging a little Bell in the Recipient of the Air-Pump, and exhausting the Air from it; of which more largely in *Contemplation XVII. §. XXXVI.*

SECT. XXII. *After what manner Vapours float.*

Now, to draw a Conclusion from all this, it is easy to be understood, how the Waters, by being united to the Sun-Beams or Fire thereof (to say nothing of the Exhalations in great Frosts) are raised up into the Air in Vapours, where, according to the Laws of Hydrostaticks, they are driven and remain

remain pendulous in a lighter Matter, as the Air is in this Case, without subsiding by their own Weight: But it would be of very little Use to all the Inhabitants of the Earth, both Men and Beasts, in case these Watry-Vapours should continue always floating in the Air, without ever falling down from thence. Now to form some Conception, how this floating of the Air may happen: Let us again suppose that from the Sea P, in the thick Air F P, (*Tab. XV. Fig. 1.*) there are some Vapours raised up to F; that at the Distance of F I G, from the Earth, the Air becoming something thinner, yet retains so much Density or Thickness, that tho' these Watry-Vapours, by reason of their not being rare or thin enough, cannot rise up higher to B, yet they are hinder'd by a sufficient Weight and Thickness of Air from falling down, and collect themselves there in high-flying Mists, which when seen from the Earth, are called Clouds, as has been already experimentally shewn; whilst others that are heavier, cannot ascend farther than to K d; because, if they came into a higher Air, which was lighter, they would fall down again.

SECT. XXIII. *Experiments to shew how the Vapours can descend.*

I. IF now two Winds blow these Mists or Clouds with any Force, as I G, or F, from opposite Quarters, and thereby compel them to run against each other, it is easy to conclude, that they will be there collected into Drops, and so becoming heavier than the like Quantity of Air, will fall down; and the rather, because by the Motion of these Winds, the Fire that render'd them lighter (after what manner soever it happens) gets an Opportunity of separating itself from them.

According to the first manner, we see in Distillations from Retorts or Glass Helms, when in the narrow Parts of their Necks, the Vapours are compressed together, that they run into Watry Drops, and so descend; tho' just before, having Room and Liberty, they did ascend, and would have risen yet higher, without these narrow Passages.

'Tis likewise well known to every one, that a hot Liquor in which there are many Particles of Fire, becomes colder by the Breath or Wind of Peoples Mouths. Now that this happens, because the Fire-Particles are by such a Motion separated from thence; seems probable for the following reason; namely, that otherwise, if the greater Heat did consist only in a greater Motion of the small Parts of a Liquid Matter, the same, according to this Hypothesis, by the blowing, which encreases the Motion of the Liquor, would become hotter, and by no means colder, whereas common Experience teaches us the contrary.

SECT. XXIV. *Vapours descend by the Separation of the Particles of Fire from them.*

II. IN case one only Wind be of so much Strength as to be able, by blowing from I to G, (*Tab. XV. Fig. 1.*) to drive forwards the Vapour or Cloud I G, in a streight Line I Z, and so can protrude the Whole or a Part thereof to Z; it is plain, that the said Cloud is higher from the Earth at Z, and consequently

Fig. 1.

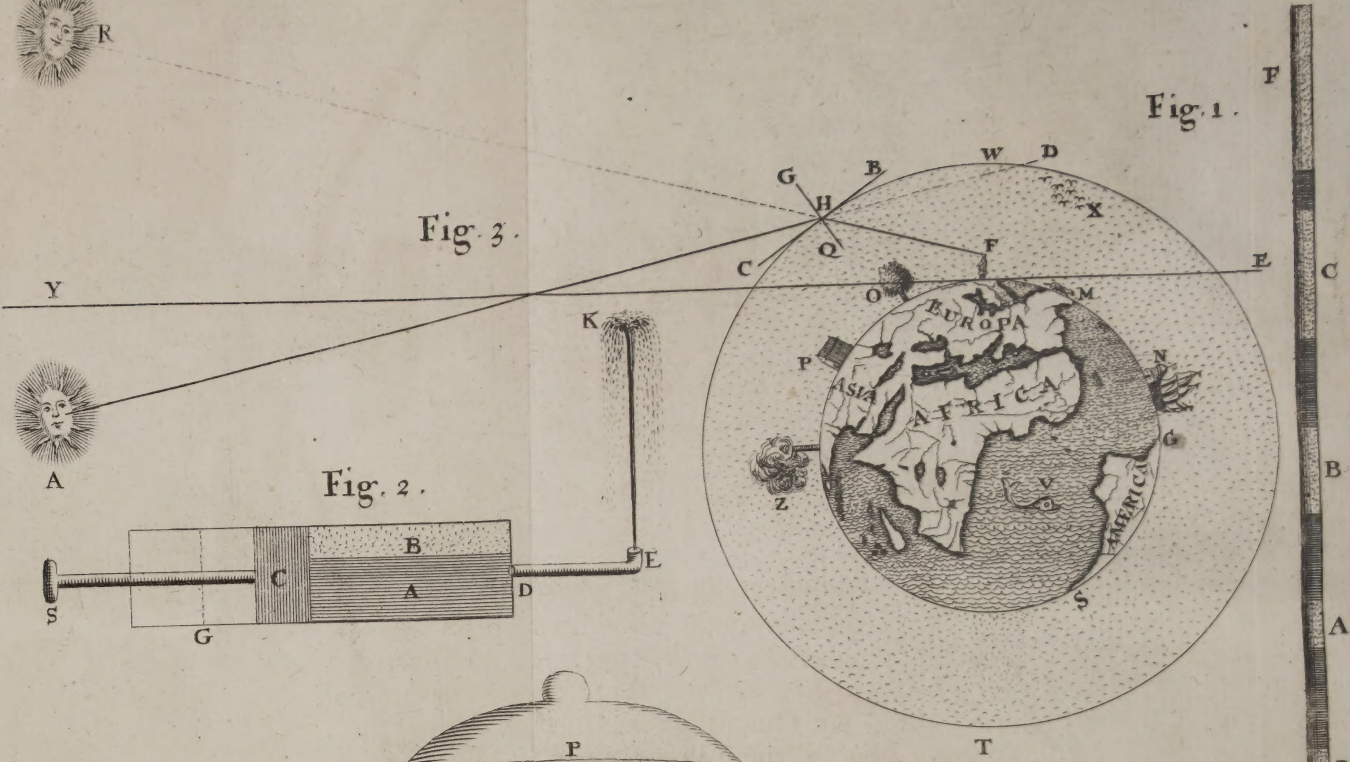


Fig. 2.

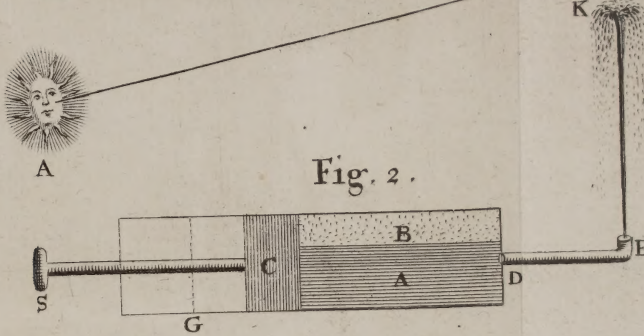


Fig. 4.

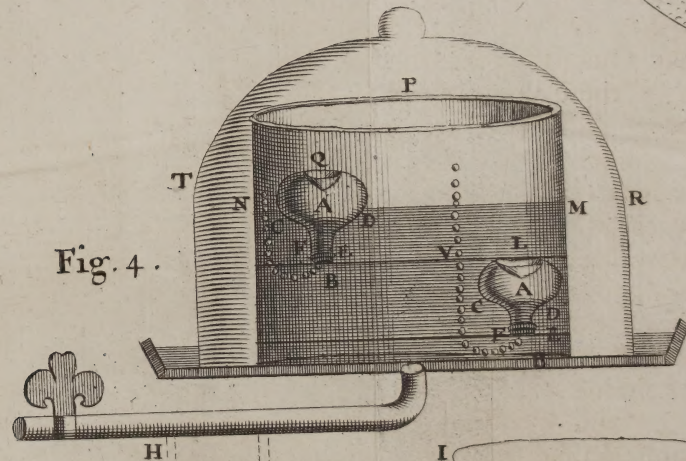


Fig. 5.

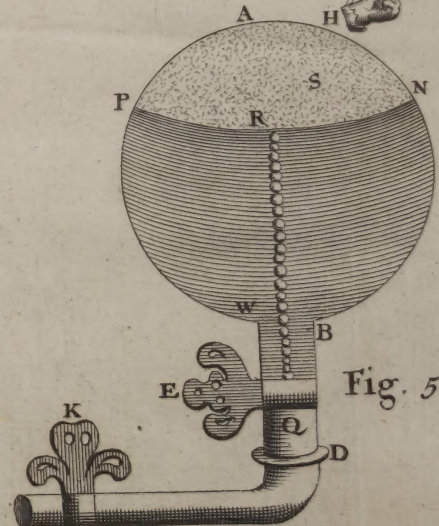


Fig. 6.

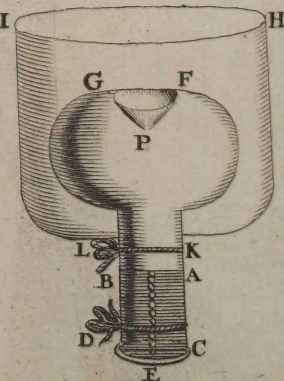
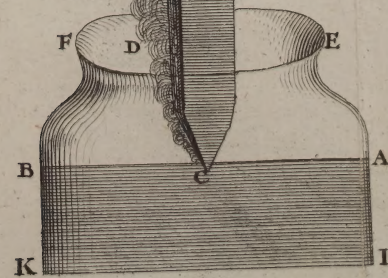


Fig. 7.



sequently in a thinner Air. From whence it will follow, according to the abovemention'd Experiments made upon hot Water and hot Lye, in the Air-Pump, that the Fire which, by sticking to the Particles of Water, render'd them lighter, will extricate itself from them, and ascending by its Lightness, the Water will become too heavy, not only to remain in this thin and light Air, but even in a thicker and a heavier near the Earth, and so will be turned into a descending Dew or Mist, or Rain, Snow, or the like, according as the Watry-Vapours are either rarified or compress'd.

SECT. XXV. *Experiments, proving the Descent of Vapours by the Air's becoming lighter.*

III. Now, that the Air (which being near the Earth at P, is otherwise heavy enough to keep up the Vapours, and to cause them to float about F) is likewise frequently, for other Reasons, turned into a thinner and lighter Substance, and so gives an Opportunity to these Vapours to descend, has been already shewn in the preceding *Contemplation*, §. XVII, and XVIII. in the Glasses of the Air-Pump; and the Barometers do, upon many occasions, furnish us with Experimental Proofs thereof; in which the Quicksilver descending commonly upon the least Weight of the Air, does prognosticate, that the Watry-Vapours are about to descend in Fogs or Vapours, or otherwise from the Air.

SECT. XXVI. *Cold will produce the same Effect: Shewn experimentally.*

IV. BESIDES this, the sudden Cessation of the Warmth of the Air seems to give an Opportunity to the Vapours, which, by the said Warmth, had been raised up in great Quantities, to be precipitated by the Cold, and to be turned into Fogs or Rain. Analogous Example thereof may be seen in Distillations that are performed by Spiral Pipes, or Worms; and something like it is also found in Chymical Crystallizations; in which we see, that the Salts that float and are dissolv'd in the Water whilst warm, do coagulate and subside as soon as the same becomes cold. But whether it happens so in the Air, or after what other manner it is done there, since the Nature of Cold is not yet so fully known to us as many think, we shall not enquire farther here.

Now how many Causes soever there may be, besides those that we have already mention'd, whereby the Watry-Vapours that are raised up in the Air may be made to descend, this is certain, that both their Ascent and Descent are owing to a wonderful Law of *Hydrostaticks*.

Now can any one imagine, that all this comes to pass without a wise Direction, and that it is by mere Chance that so vast an Army of Vapours in the great Space of the Air are every where subjected to the most exact Hydrostatical Rules, in such an infinite number of Occasions and Accidents? Is there no want of an Intelligent Being to oblige such a prodigious Quantity of Waters, turned into Clouds, to remain floating in the Air, which are often observed to descend in mighty Showers, in rainy Springs and Harvests, or other Seasons? To say nothing now of the various Ways and Forms in which they descend, and whereby so many Cisterns and other Receptacles of Water, as well

well as Ditches, Canals, and Ponds, are filled in so small a time: But which is a great deal more, by which such vast Rivers swell so suddenly, and overflowing their Banks, do frequently cover whole Districts of Land.

SECT. XXVII. *The Motion of Vapours from one Place to another, is necessary.*

BUT now if these Vapours had no other Quality or Property in them than barely an Ascent and Descent to and from the same Place, and that those, for instance, represented in *Tab. XV. Fig. 1.* by F, having been exhaled from the Sea at P, should fall down again in the very same Place; and that every Place were to be moisten'd only by no other Watry-Vapours than such as are drawn from its own Bosom, there would very little Advantage accrue to its Inhabitants from thence. How many Rivers would then be quite dried up, which at present have their Rise, or at least receive an abundance of Water from the Rains and Snows that descend from the Mountains? How should the wild Beasts in *Arabia*, and such like Countries of *Africa*, which thro' their Drought afford no Water at all, assuage their burning Thirsts? What Fruits would the now most fertile Places produce, in case none of the Water, which by the Heat of the Sun is exhaled in other Parts of the World, were brought, and made to fall down upon them?

Can a miserable Philosopher think again, that he owes no Thanks to his Creator, that the Waters which are exhaled in the *Torrid Zone*, and other hot Countries, are, by the Winds that drive Clouds, brought home to him, yielding him Drink, and making fruitful that Part of the Earth where he inhabits?

SECT. XXVIII. *An Experiment, shewing that the Watry-Vapours leave their Salts behind them.*

NOW since most of the Vapours that are so beneficial to the whole World are chiefly exhaled from the Sea, and yet those Waters, by reason of their Saltness, are unfit for the Purposes to which they are destin'd, insomuch that Men would die of Thirst in the midst of the Sea, and no Herb or Plant, to which the Salt-Water should be applied, could live and grow therewith, as by sad Experience is but too well known in Lands that have been overflow'd by the Sea: Can any one again imagine, that it is by mere Chance or ignorant Causes, that the Sun does only exhale the Fresh Watry-Vapours out of the Sea, and collect them into Clouds, whilst the Salt, with which they were at first impregnated, by reason of its being so much heavier than Water, is left behind?

That this is true, may be proved not only from the Freshness of Dew, Rain and Snow, but one may see, whenever one will, a like instance, by setting Salt-Water upon the Fire, and causing it to exhale in Vapours, or by drawing them off in Distillation; in which Case you will find the Salt remaining at the Bottom. The same we see happen in Salt-works by the Sun's Heat, and in the Salt-works with our common Fires: So that after this manner two great Things come to pass, without which the whole Race of Mankind would soon be extinct; namely, that *First*, Sea-Water is divested of its Salts, and render'd fit for Drink, and so many other Uses; and *Secondly*, that the said Salt becomes very serviceable to Men.

SECT. XXIX. *If the Earth were mathematically round, the Rains would seldom fall where they were wanted.*

NOW, if what has been said before be not sufficient to convince our unhappy Atheist, let him stop here a little, and seriously reflect with himself, after what manner those Countries that lose their Moisture by so violent and continual a Heat (and which are therefore so dry and so barren) can be brought into a Condition to support their Inhabitants with Meat and Drink : And in case he could order Matters as he thought fit, what Methods would he take, constantly to provide the same with a sufficient Quantity of Water from the Heavens, and to collect the Vapours in that vast Ocean of Air, and make them descend upon those Parts of the Earth only where they are chiefly wanted. And that we may not give him the Trouble of charging his Imagination therewith ; let him but say, whether he should not esteem that Man as a very understanding Person, who had invented a Way, which as long as Heaven, Earth, and Sea remain as they are, will always be useful, and whereby those dry and uninhabitable Countries might be so well water'd, as to be equal in Fruitfulness to any others.

SECT. XXX. *Convictions upon Occasion thereof.*

TO give an Instance of such a Case ; Let a Man cast his Eyes only upon the Island of *St. Thomas*, which is under the Line, or upon that of *St. Helena*, lying between the Tropicks, where the Heat of the Sun is exceeding strong ; since all the Vapours that ascend from the surrounding Seas, seem to be more likely to fall down again directly into the same, than upon either of these Islands, the solid Parts of which reflect the Rays of the Sun with greater Force than the fluid Parts of the Sea : Can any one think, that it happens without the wise Design of the Creator, that there are *high Mountains* found upon those Islands, where these Vapours are collected in so vast a Quantity, that they are capable of rendering whole Brooks and Rivers sufficient to provide Drink for Animals, Nourishment for Plants, and Fertility to the Earth, in such burning Regions, in great Abundance ?

SECT. XXXI. *Mountains serve to collect Watry-Vapours from the Air.*

NOW, that all that is here said is true, (whatever different Sentiments some People may conceive about the Mountains) can be proved by a Cloud of Witnesses, as well as Trials and Experiments.

Let us only peruse the Description of the Island of *St. Thomas*, in the little *Atlas* of Mercator, in which we shall find these Words ; *In the Middle of this Island there is a Mountain very full of Woods, and continually cover'd with such thick Clouds, that from the said Woods there proceed Streams and Brooks sufficient to water all the Sugar in the Plantations ; and, which is very remarkable, when the Sun is at the highest, this Mountain is mostly cover'd with Clouds.*

The same Thing is related by Mr. Robbe in his Geography, concerning the Island *Madagascar*, viz. that notwithstanding that it is so situated, as to be exposed

exposed to the strongest Heat of the Sun, which as at *St. Thomas's*, is twice a Year perpendicular over the Heads of the Inhabitants; and one would therefore be apt to think, that every Thing is destroyed with Heat and Drought, yet in the middle thereof, there are a great many Mountains and Woods from whence many Rivers are observed to run on all sides.

I find the same noted by *Mr. Warren*, or rather in his Extract in the *Act. Lips.* 1691. p. 98. *That the Clouds and Fogs hanging over and about the Mountain, called the Pike of Teneriffe, do run down every Day about Noon, in so vast a Quantity, that they do abundantly supply the Place of great Rains, which never fall upon other Parts of that Island.*

To instance in no more; that this is a useful Phenomenon in Nature, may appear from the *General Geography of Varenius*, cap. 9. §. 9. who proposes this Question, *Why there are often observed Rains, Fogs and Snows upon the Tops of Mountains, whilst in the adjacent Valleys the Weather is bright and clear, and none of these Meteors are to be found?* And then he proceeds to say; *This is confirmed by such as have travelled over the Mountains in Asia, Peru, and other Countries, viz. That they frequently observed Rain, Snow, and thick Fogs upon the Tops of those Mountains; but when they descended into the Valleys, they met with nothing but fair Weather: We find the same sometimes in the Mountains of our own Country.* Accordingly, *Mr. Ysbrantz Ides*, observed in a certain District upon the Frontiers of *China*, that the Clouds shewed themselves over the Mountains, but not farther.

SECT. XXXII. Fountains and Rivers proceed from Mountains.

MOREOVER, that Fountains and Rivers proceed from that Collection of Vapours which is continually made upon Mountains, is very learnedly proved by that great Mathematician *Dr. Halley*, whose Dissertation thereupon has been published in the *Phil. Transactions*, Numb. 189. the Substance whereof is briefly as follows; *This Speculation about Fountains is by no means a bare Supposition, but is founded upon Experience; to the acquiring of which, my Stay at the Island of St. Helena (which is likewise under the Torrid Zone, and one of the hottest Parts of the Earth) gave me an Opportunity; where, upon the Top of a Mountain about 2400 Foot above the Sea, the Vapours and Dews of the Night, even when the Sky was clear, descended so thick and so fast, that I was forced every Quarter of an Hour to wipe the Glass of my Telescope; and my Paper was in a Moment so damp, that it would not bear Ink. From whence one may conclude how great a Quantity of Water must be collected upon those Mountains in a very short space Time, which are much higher and larger than this is; and which are observed to run in a long Ridge, so long as to fill whole Countries, such as the Pyrenæan Mountains, those of the Alps, the Apennine and the Carpathian, in Europe; the Taurus, Caucasus, Imaus, and others, in Asia; the Atlas, the Mountains of the Moon, and many more that have no Name, in Africa; from whence proceed the Rivers of Nile, Niger and Zaire in America; the Andas, and the Apalatian Mountains, each of which do far exceed the common Height to which Vapours of themselves do ascend, and upon the Top of which the Air is so cold and rarified, that it can support very few of the Vapours floating in it, and which are driven thither by the Winds.*

SECT. XXXIII. *The Furnishing us with Springs and Rivers is a principal Use of Mountains.*

THE above-named Gentleman is of Opinion, and that not without weighty Reasons too, that one of the chiefest Uses of Mountains is to collect the Vapours in the Air, and to turn them afterwards into Fountains or Springs, then into Brooks, and last of all into Rivers, and so to transmit them from their respective Heights.

I shall not here enumerate the Difficulties that are proved by the said Dr. Halley, to stand in the way of those that pretend to deduce the Origin of Rivers from other Causes: Wherefore he seems to lay down the aforesaid, as almost the only ones. And it suffices for our Purpose, that tho' there were any others, yet these at least may be esteemed some of the chiefest. I have dwelt the longer upon this Matter, because it seems to serve for a great Proof of the Wisdom of the Creator, to such as will consider the whole without Prejudice.

SECT. XXXIV. *Convictions from the foregoing Observations.*

NOW, if there should still remain any of those unhappy Persons, who endeavour to maintain that every Thing has acquired its Form from necessary Causes, or mere Chance, upon the following or the like Hypotheses; namely, that so many and such amazing great Bodies as the Mountains, are of no use at all; and who, if they had had the fashioning the Globe of the Earth, according to their own Humours, they would have made it without them, and have given it a perfect round Figure, without the least Inequalities: Let them but once seriously consider the above-mention'd Experiments, and from thence learn, *First*, the great Necessity of these protuberant Parts of the Earth; without which the Globe would altogether, or at least in a very great Measure, be deprived of Rivers, Things so useful, and which are such great and noble Tokens of the Goodness of our Creator. And, *Secondly*, let them ask themselves, whether they must not be convinced thereby, that those speak nothing but the Truth, who affirm, that all these Arguments about the Usefulness of such Glorious Parts of the World, have no manner of Foundation in the Things themselves, but only in the Littleness of the Understanding of these Cavillers; and that if the Ends which the Creator had in view, were made known to them, what they urge against the Greatness of that Supream Director, would become a Demonstration of his Goodness.

SECT. XXXV. *Egypt moisten'd by the Nile without Water.*

I MUST confess, that it has many Times appeared to me as a sensible and visible Proof of the gracious Providence and Government of GOD, namely, what has been published and confirmed by the General Testimony of all that have travelled there, concerning the particular State and Condition of *Egypt*: This Land, which is all Flat, and without any Mountains, as *Monconys* and others write, is seldom or never water'd by Rain: it lies in the

middle of dry Countries, and is almost surrounded with the most barren Deserts, insomuch, that of itself it is entirely unfruitful, and consequently would be uninhabited.

Now can any one imagine, that it comes to pass by mere Chance, that the Mountains of the Moon are placed in those Parts of *Africa* where the Countries are burnt up with the Sun, and that from the said Mountains there flow such mighty Streams, which, being collected together, make the Sea or Lake of *Zaire*, from whence proceeds the River *Nile*, which running thro' all *Egypt*, discharges itself by many Mouths into the *Mediterranean* Sea; and, which is most for our present Purpose, that it yearly swells and rises over its Banks, and overflows all the Country; so that the Towns that are built upon any Eminences appear like so many Islands, whilst the flat Country lies under Water; and by such Inundations this Country, which is otherwise dry, and almost burnt up, becomes as fruitful as any other that is usually water'd with Rains.

SECT. XXXVI. *The Fertility of Egypt.*

IT is wonderful what the Geographers, and among them Mr. *Robbe* in his Description of the World, mentions of the Fertility of this Country; namely, that these Waters of the *Nile*, with which all *Egypt* is over-flown, are wont to leave such a Slime and Mud behind 'em, as, being dried, renders the Ground so very fertile, that the Trees are almost laden with Fruits; and that if the *Egyptians* themselves were not so lazy, but would Cultivate and Sow their Lands after the first Harvest and Collection of the Produce, they would yield a second Crop in the same Year: This is certain, that by reason of the Strength and Fatness of their Country, the Inhabitants are oftentimes obliged to moderate the same, by mixing Sand with the Earth. Many do likewise ascribe it to this Cause, that their Flocks are more numerous than in other Countries, and that their Sheep bring forth Young twice a Year, and the like: Some Authors say the same of their Women, that they have often Twins, and sometimes more at a Birth.

SECT. XXXVII. *Convictions from the foregoing Observations.*

TO return now to that Cause of the Rivers, the Collection of Watry Vapours upon Mountains: They that are still so stark blind or stiff-necked, that they cannot, or will not, see any Tokens of Divine Wisdom and Goodness in each of these Wonders; Let them again Contemplate some of them with us, and return to *Tab. XV. Fig. 1.*

Let them then suppose, that upon the Globe *W K R S* there dwell a Number of Men and other Creatures, in the Structure and Composition of each of which there appears, as has been shewn before, an amazing Skill and Contrivance.

Let them next own, as it is true, that unless the Earth *C X Y T* were moisten'd with Water, and that fresh too, the said Earth would be entirely Barren, and all the Living Creatures upon it would perish with Hunger and Thirst; and tho' an abundant Procreation might seem capable of making good

the Loss, yet none of their Young could live a Month after it was brought forth.

Let them consider, that those great Seas, and vast and deep Lakes C W S, how great a Quantity soever of Water they may contain, would not be able to render the smallest Tract of Land-fruitful ; nor to afford to one single Man or Beast so much Drink as were necessary to keep them alive, by reason of their Saltness.

Can they then in this dismal State of Affairs imagine, that it is by Chance, and without any Wisdom, that such a glorious Body as the Sun, besides the Light and Warmth it communicates to us, does also render us this Service, that the Waters of the Sea at P, being rarified by its Beams, are exhaled, and ascend in Vapours to g and F ; and, leaving their Salts behind them for other Uses, do compose the Clouds, F, I, G, K d, above in the Air ; which falling down again in Rains or Fogs, in Dews, Hail or Snow, afford a fresh and fertilizing Moisture to the Earth, and Drink to Men and Beast ?

Can he daily see this Ascent of Watry Vapours, and say that it is performed by Chance and without Wisdom ? Notwithstanding the Manner by which 'tis brought about, is allowed to be wonderful, by the greatest Naturalists, such as those learned Persons, Dr. Halley and Mr. Mariotte, who are not ashamed to acknowledge the Weakness of their Understanding in that Matter, and so must every one besides. And yet all this great Preparation would have been in vain, if a certain fluid Matter, which we call Air, had not been placed round the Globe at B A D.

But that which here seems to prove undeniably the Being of a God is, that notwithstanding the Terrestrial Globe be thus surrounded with Air, and that the Sun does continually shine upon the Sea and the Rivers, yet there would scarce arise from thence the smallest Vapours, if the said Air were as thin and as much rarified below at F P as it is above, between B and F ; and on the contrary, if the Air were as thick above, between B and F, as we now find it between P and F, few or none of the exhaled Vapours would ever descend in Rain or Dews, but floating in the Air, like Oil upon Water, would continue there ; in which case also, the whole Earth would be dried up, and every thing living perish with Thirst.

Let me now again ask these miserable Philosophers, whether they can imagine, that all these things are thus disposed by mere Chance, and without a View towards any End ? And that the Air, by its Weight and Elasticity, becoming more Compressed and Thicker below than above, was thus disposed with respect to the exhaled Watry Particles, that the Vapours would be seldom or never in an Equiponderating State therein, before they be raised to the height of the Clouds F or K. Whereas otherwise, in case the Air were of the same Thinness at P, or just above the Earth, as it is higher at F, to say nothing of the Distempers which would be occasion'd thereby, the continual Cloudy Weather, Fogs and Mists, would take away, or at least embarrass the use of our Sight.

To add one thing more ; Is it brought about by ignorant Causes, and without Knowledge and Foresight, that whereas so many other Kinds of

Salts are incomparably lighter than Water, yet the Sea-Salt is heavier? Which would otherwise, by ascending along with the Vapours, render all the Waters of Rain and Rivers uselefs and unnecessary, both to Living Creatures and Plants. Is it by Chance, that the Sun is placed at just such a Distance from the Globe, as to be able by its Warmth to cause the Waters to ascend in Vapours; and yet not so near as to singe and burn up those tender Plants which received their Nourishment and Encrease from those Waters, and do chiefly consist thereof?

Have the Sun, the Sea, the Air, and the Salt, met one another in so small a Corner of the World, which, with regard to the whole Extent thereof, is but a Point; I say, have they thus met by mere Chance, in order to furnish all the Inhabitants of the Earth with Meat and Drink? Is it owing to Ignorant Causes, that they are endowed with so many necessary Qualities as have been before enumerated, and as are required for this only Purpose? If this be not sufficient; if no other Causes concurred, in order to water the Earth with the Vapours descending from the Air, than the Lightness and Thinness of the said Air, or the Winds that drive them together, it is plain to every Body, that all the Parts of the Earth, without any Difference, would be equally water'd; and that the Sea, which has no occasion for these Vapours, as well as those other Parts of the World, which for want of 'em would be uninhabitable, would each receive their Share; and it may be, those that least want them would enjoy the most.

Once more, let those Philosophers with whom we have here to do, judge themselves, whether it be owing to mere Chance, that to the end, that those Countries which stand in most need of being water'd, may enjoy a greater Share than others, such great Bodies as the Ridges of Hills and Mountains, are placed in or near the same. The Use of which, as has been said before, is to intercept the Watry Vapours floating in the Air, to collect them in a particular manner upon their Summits or Tops, to drive them down from thence, and so to furnish such a Quantity of Water as may compose the requisite Brooks and Rivers which contribute so much to the Benefit of the Earth, and the Inhabitants thereof; and which running down from these Hills, from whence they derive their Source and Beginning, they moisten the surrounding Lands, which would otherwise be barren thro' Heat and Drought, and render them fit to support their Inhabitants with Meat and Drink.

To say nothing here of the number of Fishes and other Productions in these Waters, by the help of which the People, thro' whose Countries they flow, can communicate their Fruits and Merchandizes to each other.

SECT. XXXVIII. *The Mountains collect Watry Vapours, first by the Winds.*

HERE we seem to have a proper Occasion to inquire into the Manner and Causes, how and why the Mountains are able to collect such a vast Quantity of Waters, to the end, that what has been said before upon this Subject, may be the more clearly understood.

How the Vapours are raised from the Sea, from P to g and F (*Tab. XV. Fig. 1.*) by the Warmth of the Sun (and under the Poles, by Cold too perhaps) has already, in some manner, been endeavour'd to be shewn; as also how they are enabled to float in thin Air, as in different Stages and Degrees of Height, as g, K, d and F, I, G; and moreover, why the said Vapours, being raised higher up to Z, by the Winds, or driven against one another by contrary Winds, and for other Reasons, do descend in Rain, Snow, and the like.

Dr. Halley subjoins another Manner to these; namely, that a floating Vapour or Cloud in E, being driven against the Mountain QNR, by the Winds at E, ascends to the Top N, and there being got into a lighter Air, cannot be any longer sustain'd, but falls down in small Drops upon the Head of the Mountain, and from thence running down, fill the Cavities of the Mountains (which are supposed to be there, and so are often found to be) with Water; which running continually thro' the Orifice M, produces the little Brook M e T, or M e V; which joyning themselves with others of the like Nature, form a large River.

It appears by this way, why the Waters are assembled in greater Quantities upon the Mountains, forasmuch as opposing their Tops from QR to N, against the Winds which drive the Clouds m E, K d, &c. they serve for Barricado's or Cross Trees, and so do either force the Vapours to ascend into a Lighter Air, or forcing them against those Tops, squeeze them together, whereby they become heavy and fall down again.

SECT. XXXIX. *Secondly, Vapours are collected by the Coldness of the Mountains and Superior Air.*

AND as it is credible that this does often happen, it should seem that the Winds are necessary thereto; and that in case they failed, so great a Quantity of Water, according to all Appearance, would not be collected; whereas the above-mention'd Experiments teach us, that the Tops of the Mountains, even in hot Countries, are not only encompassed by Winds at certain times, but continually with Fogs and Vapours; so that besides this, it seems that a more settled Cause, and which does not always depend on the Motion of the Winds, must obtain here.

Now, whether this can be deduced from the Cold of the Mountains themselves, and of the Superior Air surrounding their Tops, and to which the Reflection of the Sun-Beams does not reach; or, whether it must be ascribed to their Heads being always hid in the Clouds, I leave to such as will enquire more strictly: This is certain, that by reason of the Cold, they are often cover'd with Snow; and Varenus says, that excepting in the Months of July and August, there is always Snow upon the Pike of Teneriff; tho' none can be found in this and the other Canary Islands.

SECT. XL. *Thirdly, Vapours are collected by Shadows, shewn Experimentally.*

WE have not here undertaken to write largely upon Natural Knowledge, nor to repeat the whole History of Nature; but we cannot forbear observing
however,

however, that the great Shadows which these Mountains produce, do occasion a continual Cold Air about them. Thus we read in the *Extract of the History of Eohemia, Act. Lips.* 1682. p. 244. That in a certain Valley of the Giant Mountains, at the hottest Time of the Year, there are very deep Snows, and that they have lasted there for 16 Years together, the old being of brownish Colours, by which it is distinguished from the latter Snows that are white and clear.

If then we suppose the Sun to be at O (*Tab. XV. Fig. 1.*) and a Mountain QNR, casting its Shadow, as at QEX; where the Sun-Beams are hinder'd either by other Mountains lying about it, or, because the Sun seldom shines upon that Side, from ever heating the Air to such a Degree as is found in the next adjacent Air: It is plain, that the Air within the Shadow QEX, will be a great deal Colder than that which encompasses the Mountain out of the Shadow. Now it has been proved experimentally in the foregoing *Contemplation*, that a warmer Air having access to another which is colder, if they be not of a too different Thickness, will be rarified and driven with a Wind and Stream towards the cold Air. Now if this should be applied to the Air, which is here not only below, but also above, and on the Side, or rather round about the Shadow, we shall see how this Air, with all the Vapours in it, are driven to the Shadow: for that the Vapours floating in the Air do continually follow its Course, is plain, and will appear from a boiling and steaming Pot of Water, set in a place where there is no Wind: From whence then it may be concluded, that the Air with its Vapours, coming into such a Shadow, and being there deprived of its Elastic Force by the Cold, will be immediately followed by more Air which is warmer, and consequently whose Elasticity is stronger, and so produce an entire and gentle Stream of Air and Vapours, if not prevented by other Winds, and moisten those Places with continual Vapours.

SECT. XLI. *Fourthly, Other Shadows likewise give occasion to the Concourse of Vapours, proved Experimentally.*

Now, that this also, among other Reasons, must be laid down, why the Vapours seem to be drawn in a continual Stream to the Mountains (but really and properly are pressed thicker from all Sides) and why the Mountains are many times observed to be clouded (of which we have given several Instances above) every one that understands the Properties of the Air, may easily infer from what has been said. That in Shadows the Vapours of the Air are collected, does certainly appear from the Night, which is nothing but the Shadow of the Earth, and in which it is well known, that the Vapours and Dews fall thicker than in the Day-time. Thus we see the Descent of Vapours in the Night-time was observ'd by Dr. Halley, in the Island of *St. Helena*. And we find in the *Memoirs of the Royal Academy of France*, for the Year 1693. p. 128. a Method invented by Mr. de la Hire, to hinder the Dews of the Night from sticking to the Glasses of the Telescopes. Now Experience teaches, that in the Mornings too, the Mountains are moisten'd with Vapours (*see Varenius's General Geography, Lib. 1. §. 5.*
p. 157.)

p. 157.) because those Places that are within the Shadow of the Mountains, are much Colder at Night than other Places that are out of the Shadow. Thus we likewise see from what has been said, that in the Islands of *St. Thomas* and *Madagascar*, the Mountains which collect the Waters from whence the Rivers are produced, being cover'd with Woods, and consequently more shady, do make the Air more cool and more elastick; by which Means the Waters are yet more encreased upon the same: And that it may not be thought that this is inconsistent with what has been said above, of the Descent of the Waters more strongly at Noon, from the Mountain called the *Pike of Teneriff*; let it be consider'd, what was farther said about this Mountain, namely, that the Snow which cover'd the Top of the same, being melted by the Heat of the Sun at Noon, caused the Waters to run down more violently at that Time.

I think that these Experiment may serve for Proofs, that the Cold produced by the Shadows of the Mountains in the Air, may justly be accounted one of the Reasons why so many Watry Vapours are carried thither in a continual Stream.

SECT. XLII. *Vapours sufficient to produce Rivers.*

THE only Difficulty that seems to remain, how there can ascend so great a Quantity of Vapours as may suffice to produce great Rivers: To answer which, we do not here pretend to maintain, that all Rivers proceed from these Vapours, or that they are the only Cause thereof; since perhaps, according to the Opinion of others, the Sea entering into Subterraneous Caverns, may, by way of Filtration, leave its Salts behind it, and so produce Sweet and Fresh Fountains: And besides it may be, the Subterraneous Fires may cause these Waters that come from the Sea into the Cavities of the Earth, to exhale and ascend in Vapours, which being again turned into Water by the Cold which they meet with above, may produce Fountains. But it is however a sufficiently probable Truth from what has been shewn before, that the said Vapours may justly be reckon'd among the principal Causes of Rivers. Since the Sea, and other Waters exposed to the Sun, do continually transmit Vapours upwards, which being collected upon the Mountains, and coming down again in Rain, Snow, or Hail, are proper to produce Rivers which may flow a long Time without ceasing, and supply great Streams. This may be in some manner inferr'd from the Observations of Mr. *Mariotte* in his Treatise *du Mouvement des Eaux* (*Engl. Translation*, p. 18.) who says, that at the lower end of a heap of Rubbish, which was about three Foot high, and whose Superfices was about 500 *French* Fathoms (forasmuch as the Rain that fell upon it, and ran down upon it from the Tops of the neighbouring Houses, could not soak thro' by reason of the Hardness of the Ground) there was a continual little Stream of Water.

But the same will be yet better shewn hereafter, from the Calculation which the said Mr. *Mariotte* makes, concerning the Waters of the *Seine*, compared with the quantity of Rain falling upon those Tracts of Land from whence this River has its Origin. See the said Treatise, *English Translation*, pag. 22, 23, 24.)

by which it is proved, that in case there falls so much Rain-Water every Year upon these Lands, that in case it remained there, would rise to the Height of 15 Inches, there would be 6 times as much as is requisite to run down the Seine in one Year; and in case the Height of such Rain-Water should amount to 18 Inches, there would be 8 times as much; as likewise, if you should suppose it to rise to 20 Inches, there would fall 9 times as much Water upon those Places, as flows thro' the Bed of the said River.

SECT. XLIII. *The Method of computing the Quantity of Rain-Water falling in a certain Time.*

THE Method which Mr. Mariotte makes use of to compute the Quantity of the said Rain-Water, is this; he took a square Vessel, which, for instance was two Foot in Length, and as much in Breadth, which was raised upon a Horizontal Iron in such a manner that no Water could come into it, but what descended immediately from the Sky into the Square of the Orifice thereof. This Water was conveyed by a Tube down into a round Vessel, from whence it would not be evaporated; so, that by Gaging the Water in the said round Vessel, it could be known how high it would have risen from the Bottom of the Square Cistern: And supposing that there fell as much Water in one Year upon one Place, as upon another, one might compute pretty near the Depth of the Rain that would fall upon the circumjacent Land in the space of one Year.

SECT. XLIV. *The Rain of Paris compared with that of Lisle.*

Mr. Mariotte says farther, that this Experiment having been made at *Dijon*, he found it to amount to 17 Inches; and another Person that tried the same, computed it to 19 Inches $2\frac{1}{2}$ Lines. But they that desire to see a very accurate Calculation and Comparison thereof, may find the same in the *Memoirs of the Royal French Academy*, 1699. p. 25. for 6 Years following, one of which was made by Mr. *Vauban* at *Lisle*; and t'other by Mr. *de la Hire* at *Paris*, in the following Manner:

Years	<i>Lisle.</i>		<i>Paris.</i>	
	Inches.	Lines.	Inches.	Lines.
1689	18	9	18	$11\frac{1}{2}$
1690	24	8	23	$3\frac{3}{4}$
1691	15	2	14	$5\frac{1}{4}$
1692	25	$4\frac{1}{2}$	22	$7\frac{1}{2}$
1693	30	$3\frac{1}{2}$	22	8
1694	19	3	19	9
	133	$6\frac{1}{2}$	121	9

And thus the Rain-Water that falls at *Lisle* every Year, amounts to the Height of 20 Inches and 3 Lines, as that at *Paris* does to 20 Inches $3\frac{1}{2}$ Lines, or, at Medium of both, 21 Inches.

SECT. XLV. *Rain Water alone sufficient for Rivers.*

FROM hence, tho' it be plain, that there falls more Rain in one Place than in another, within the same Space of Time, yet to make a general middle Computation, it may be safely advanced, that there falls about 20 Inches of Rain yearly upon the Earth, and consequently 9 times as much as was necessary to fill the River *Seine* in one Year. So that, tho' we should deduct from thence all that is serviceable to other Uses, and to the moistening and fertilizing the Ground, and all that evaporates from it as soon as it is fallen; yet the Rain alone, without the help of other Vapours, furnishes Water enough to maintain a far greater River than the *Seine*; which, if it happen'd in all Places of the Globe, and that many of these little Streams should be collected into one great and common Stream, they would together make up mighty Rivers. Accordingly, we find by Experience, that by reason of the Quantity of Waters which they bring with them, famous Rivers are produced by the Concourse of several others that are lesser; which the Rain-Waters, falling upon many great Parts of the Earth, discharge therein.

SECT. XLVI. *There is more Water in the Air than what descends in Rain.*

WE may now infer from what has been said, that the Vapours which descend in Rain only, seem to be more than sufficient to supply the Rivers but that, besides this, the Air does yet abound with a very great Quantity of Waters, may appear:

I. Because those Waters disclose themselves in Mists, Dews, and Nocturnal Moistures, and oftentimes do likewise descend in invisible Vapours.

II. Thus we find in the making of the *Hygrometers*, or *Notiometers*, or those Machines by which we measure the Moisture of the Air, as we do the Weight thereof by *Barometers*, and the Warmth by *Thermometers*, that the Strings of Musical Instruments, Ropes, Wood, and other Things, do undergo continual Changes by these Vapours floating in Air, according as they do more or less abound.

III. The Chymists are particularly sensible thereof, who, when they have reduced their Lixivial Salts to pure and true Alcaline as they call them, with all their Caution can hardly prevent them from being dissolved by the aforesaid moist Vapours.

And I have often thought, when I found good Salt of Tartar within Doors, and in a Laboratory, turned into a clear Liquor, that there must be a very great Quantity of these invisible Vapours continually floating in the Air, since, that in so small a Place, in so short a Time, and in so little an Orifice or Mouth, as that of the Glass containing the said Salt, there could be so much Water gather'd together; for which reason Mr. de la Hire himself (*see the Memoirs of the Royal Academy, for 1703. p. 78.*) seems to suspect, that Stones likewise, in which there were found any Salts proper to draw Waters to them, might serve to collect the like Vapours into Springs or Rills; at least, the Experiment which he there relates, that even in Places where it does not Rain

at all, as in a Cellar, for Instance, a considerable quantity of moist Vapours may be found.

V. But this appears yet more plainly from what the said Mr. *de la Hire*, p. 77. says farther, that there were a great many Experiments made, by which it was proved, that if you set a very large Vessel with Water in the Air, there will much more Water evaporate out of it than can descend from the Air upon the like Breadth.

SECT. XLVII. *Exhalations from Canals and Ditches.*

To make a rough Guess thereof, a certain curious Miller, whom I asked, How much he thought the Water in the Meadow where his Mill was, could be diminished in one Day by the Heat of the Sun? Answer'd me, that in a very warm Day there was (to speak within Bounds) at least the quantity of an Inch in Depth, especially, if the hot Weather continued any time, and by that means his Waters could not be much encreased by those that ran down from the Lands about him; for otherwise it did not appear to him, that he lost so much Water: But those who have ever seen how much Water is exhaled from the Canals or Ditches in a very little space of Time, especially when the Ground is dried by a continual Heat, will not judge, that we exceed the Truth, in allowing an Inch a Day in very hot Weather.

For this purpose, in the beginning of *June*, 1710, I filled a flat Earthen Pan with Water, and set it in the open Air in a bright and clear Day, and examining it after four and twenty Hours, I found that there was a full Inch lost in the Depth of it, by Exhalation.

Now, if we suppose, that the Evaporation of all the Waters throughout the whole Earth be equally great, and amounts to an Inch a Day, according to this Calculation, there would be every Year 365 Inches in Depth drawn into the Air: All which, supposing it to fall down again in Rain, would be capable of overflowing the whole Superficies of the Earth 365 Inches high in one Year.

SECT. XLVIII. *Experiments to shew, that Evaporations are likewise performed by Cold.*

LET it not be objected against us, that there cannot be so much Water exhaled under and near the Poles, by reason of the Coldness of those Parts of the World, because,

I. In the very sharpest Frosts, Vapours do continually ascend from our Canals and Ditches upon breaking the Ice: Now in order to enquire whether this, as some think, might likewise proceed from the Subterraneous Heat; upon the 14th *January*, 1709, which, as every Body knows, was a violent and uncommon Frost, I took an Earthen Bason, and pouring 40 Ounces of Water into it, put it into Scales in a Room where there was no Fire at all made, and found that upon its freezing, it had lost in 17 or 18 Hours, above a quarter of an Ounce in Weight; having taken care to prevent the breaking of the Vessel upon the Waters freezing, by keeping a little Hole in the middle of the Ice always open; thro' which the Water being continually pressed

pressed from under the Ice, it made a great Convexity and Protuberance above the Superficies of the said Ice; a sure Sign that Water is both moved and rarified even by Cold. And so before, upon the 8th of *January*, in the same Year, a quantity of Snow being put into the Scales, suffer'd a visible Diminution of its Weight; notwithstanding that it had fallen above three Days before, and lain all the time in the Air; and that which is more, we find even Ice itself will evaporate in the coldest Nights; as have been likewise observed by Mr. *Boyle*, in his Book, *de Atmosphær. Corp. Consist.*

And whilst I am writing this, a Person that has been one and twenty times in *Greenland*, tells me, that when the Weather is Calm, and without Wind, the Sea frequently smoaks and emits a visible Steam, which *Varenius* does also confirm, p. 361. where, speaking of the Seasons in the *Frigid Zone*, he says, that a heavy, foggy, and thick Vapour floated over the Water, inso-much that Peoples Sight was intercepted thereby: From all which it follows, that a great quantity of Vapours ascends from Water in the coldest Regions of the World.

SECT. XLIX. *Objections answer'd.*

NOW if it should be supposed and granted, that the Waters produced by the Exhalations of these Vapours, do not near amount to the quantity of an Inch a Day, as in our warm Climates; we may set against it, that the Heat of the Southern Regions, quite as far as the *Equator*, is much greater than that of ours. And again, that the Superficies of the Earth between us, who lye in about the Latitude of 52 Degrees, and the North Pole, is much smaller than that which is between the Parallel inhabited by us, and the *Equator*: Wherefore, the Parts of the Earth, where the Air is much hotter than with us, are incomparably larger than those where it is much colder. So that we shall not seem to have made any great Mistake in taking the quantity of our own Exhalations, or that of an Inch a Day, for a *Medium* common to the whole Superficies of the Earth.

But, so far as the Terrestrial Globe is not cover'd with Water all round, let us, for greater Certainty, suppose farther, that the Seas, Rivers, and Lakes, do take up no more than half the Superficies thereof: Then the Vapours that are daily attracted, to the quantity of one Inch in Depth, will cover the whole Face of the Earth, when they descend in one Year no more than the half of 365, that is to say, only $282\frac{1}{2}$ Inches deep.

SECT. L. *A Calculation after the Rate of an Half-Inch daily Exhalation.*

NOW if the daily Exhalation of one Inch should appear too large a Computation, let us suppose it to be half as much.

This seems to be more probable, for the following Reasons: *First*, Because Dr. *Halley* (by keeping a Thermometer with Salt-Water continually in that Degree of Warmth in which he had observ'd the Air to be in a hot Day) found upon trial, and by Weight, that the Superficies of that Water was in the Space of two Hours fallen $\frac{1}{8}$ of an Inch, that is in 12 Hours $\frac{3}{4}$, or in 25 Hours $\frac{1}{2}$ of an Inch, supposing the Exhalation to be always equal.

And

And again ; forasmuch as the above-mention'd Miller had, at my Request, with great Exactness observed, that from *Tuesday* the 7th of *June*, 1712, to the same Hour the following *Friday*, the 10th, the Water in the *Purmer-Meer*, or Lake, had lost of its Depth $1\frac{1}{2}$ Inch, that is to say, every Day half an Inch, tho' the Weather was then much cooler than the preceding Days ; and he would have proceeded farther in these Observations, if the Weather had not begun to be rainy and windy. After which, the Air being again warmer and calmer, he informed me, that in three other Days there were evaporated two compleat *Rynland* Inches, which is so much more than half an Inch a Day ; and therefore, if we suppose the quantity of Exhalations to amount to no more than half an Inch every Day, and the Superficies of Land and Water to be exactly equal to one another, the Rain that will fall upon the whole Earth, will amount to the half of one $181\frac{1}{2}$, that is about 90 Inches in Depth ; in case all the Exhalations should fall down again in Rain.

But now Experience teaches us, that the quantity of Rain does not amount to more than about 20 Inches. Wherefore there must be $4\frac{1}{2}$ times as much Water exhaled as descends in Rain ; for $4\frac{1}{2}$ times makes 90. So, that if the Rain be subtracted from thence, there will still remain $3\frac{1}{2}$ times as many Vapours floating in the Air, in order to come down from the Mountains, and to serve for the Uses of Plants and other Necessaries.

So that from hence it may appear in Gross, not only that besides the Rain, there is a large Army of Vapours, of three times as great a quantity, continually floating in the Air, but also a superabundant Number of Exhalations from the Water, which alone rising to the height of 20 Inches, as we have shewn before, yield nine times as much Water as is necessary to supply the *Seine*. So that the same being increased to 90 Inches, are adapted to afford above 40 times as much Water as the said River requires.

Wherefore, altho' the Plants stand in need of a great Quantity of Water, and indeed of more than one could imagine, as well as more than all the Rain can supply (as may be seen by the Experiment made by Mr. de la Hire, and recited in the *Memoirs of the French Academy*, 1703, p. 73, and 74.) nor could the Rain-Water, according to the Observations of that Philosopher, sink deep enough into the Earth ; yet the Mountains, by this Surplus of Vapours, seem adapted to supply and maintain the Rivers.

SECT. LI. *Convictions from the foregoing Observations, and a Word about the Air-Salt.*

NOW to make an end of this Matter ; let the miserable Caviller, who hitherto would not own that there is a God that governs the World, seriously reflect upon this astonishing Circulation of so vast a quantity of Waters, which ascending from the Seas, Rivers and Lakes up into the Air, are there preserv'd in Clouds ; and passing a second time thro' the said Air, are made to descend again, partly in the form of Mists, Hail, Snow and otherwise for various Purposes ; and partly coming down from the Mountains, make up those great Rivers, which again discharging their Waters into the Sea, and

and from thence again being raised up in Vapours, have incessantly, and for the Space of so many Ages, taken the same Course, and thereby supply'd all Living Creatures with Drink, fructified the Ground, and render'd innumerable Services to the whole World. And can he still imagine that it is without a Design, since the whole Ocean, by reason of its Saltness, is entirely useless for these Purposes, that by the Warmth of the Sun (to say nothing here of other Causes which may likewise concur) the Waters of the said Ocean being divided into the minutest Particles in their Ascent, leave all their Salts behind them for other Uses; which Salts would be prejudicial to most of the Fruits of the Earth, and render the Water useless for quenching Thirst, or affording Drink to Animals; and farther, that the said Water passing thro' the Air in Rain, Dew, and other Forms, should impregnate itself with the Salts of the Air and other Parts thereof, in order to become more useful for the aforementioned Purposes?

Now, whether this Salt of the Air be only Nitrous, as some pretend, we shall not here dispute; but shall take some notice of it hereafter: This is certain, that Salt-petre is likewise produced by the Air, and that the same does contribute, *First*, to the rendring the Water more fructifying, which the Ancient and Modern Gardiners knew well enough, and of which we may see a remarkable Experiment in the Transactions of the *French Academy* 1699. p. 74, and 76. And, *Secondly*, that this same Nitrous Salt, how much soever it has of the Nature of Salt, is yet a principal Means for extinguishing Thirst, as most Physicians know very well. Let the Atheist consider all this with himself, and see whether he can, with a good Conscience, pretend to reconcile it with mere Chance or Ignorant Causes.

SECT. LII. *The Wonders of the Nile.*

AND now we are speaking of Salt-petre and of Rivers; can one believe that it is by Chance that the *Nile* in *Egypt*, which overflows and renders the Country fruitful without Rain, carries so much Salt-petre with it, that a great quantity thereof may be made only by evaporating the Waters of the said River; (*See de Stair Physilogia de Nitro*) insomuch, that this exceeding dry Land becomes so fruitful, as to exceed most of the other Parts of the World. Now if any King or Prince had been so fortunate as to have brought this to pass, and to have found out a Method of watering such a vast Extent of Land every Year with so fructifying a Liquor, and without any Labour of Men, would not this have been recorded to his Praise, as a Wonder of Wisdom, by the latest Posterity? And now that we see this happen in the most glorious Manner, exceeding the Power of the greatest Sovereigns, and with so much Advantage, as to preserve the Lives of thousands of Men, and to render this Country, which in its own Nature is one of the most barren Parts of the World, many times a Magazine and Granary for other Nations that have been distressed by Famine (as we are informed by History:) Can any Body satisfy themselves in affirming, that this was done without Design, and by mere Chance? Let such an Infidel or Sceptick only compute how many Things must here concur, to render a Country

so dry as *Egypt*, and which is never moisten'd with Rain, Fruitful and Plentiful to so high a Degree. 1. There must be Water, and in so hot a Country, that Water must be brought from some other Parts. 2. For that reason this Country must be lower than almost all the rest of *Africa*, where the *Nile* has its Rise, in order to be over-flowed by that River. 3. And in other Parts it must be higher and more raised, to the end, that, during the Inundation, People may inhabit there; and so it is observed to be about the Places where their Towns are built, which at the Time of their over-flowing appear like so many Islands. 4. There must be so much Water, in order to run over its Banks, and to drown the whole Country. 5. After the Inundation, it must lie a while upon the Ground, to the end, that during its Stagnation, it may deposit the Slime or Mud which it brings along with it. 6. The Water, that it may occasion so great and uncommon Fruitfulness, must be impregnated with a sufficient Quantity of Salt-petre, but not with too much of it; which does not happen in Places where it rains enough, or in any Rivers that I ever heard of. 7. This Water must likewise run off again of itself from the Lands which it over-flow'd, and leave them dry, in order to produce their respective Fruits.

Now, if we should allow that all these Qualities are not peculiar to the *Nile*, so far as we read that the *Indus*, *Ganges*, *Niger*, *Zaire*, and other Rivers, do fertilize also their adjacent Countries by Inundations; will any one infer from thence, that because there is a God who has exerted his Wisdom, Power, and Goodness, in more Places than one, therefore he is endow'd with none of those Perfections?

SECT. LIII. *Convictions from the foregoing Observations.*

BUT to return from this small Digression, and to shew with how glorious a Lustre infinite Wisdom appears in the Use of Mountains, and the Benefit it communicates to the World by this Circulation of the Waters, and Production of such necessary Rivers; Let a Sceptical Philosopher lay before himself a Map of all the Countries of the World, and attentively view the numerous Rivers therein, which are dispersed throughout like so many rich Fish-Ponds; which, by their sweet Waters, furnish all Things living with Drink, and afford an Opportunity to the most distant Countries mutually to communicate their respective Productions: And let him tell us, whether, if there were no such thing to be found upon the Earth, he would not be obliged to own, with us, that the World would be in a very miserable Condition. And altho' the same Quantity of Water were to be met with in some stagnating Lakes and Marshes in the lowest Countries of all, is it not plain, that the higher Regions, at least where it never once Rains, as *Egypt*, *Peru*, and the like, would be ruin'd with Droughts: Not to mention, that in a great Collection of Waters, by reason of their Stagnating, in process of Time, an unavoidable Destruction would hang over their Heads. Again, can it be pretended, that it is by mere Chance, that there are such a number of Fountains found in all Parts of the World, out of which at first little Rills and Brooks proceed, which joining together, compose great Rivers; by which

which means the very driest Countries are furnished with Water, and that with Running and Living Waters too, which, by its continual Motion, is preserv'd from Corruption? Now this could by no means happen, if there were not Mountains in some low, and even high Countries too, upon which the Vapours being collected, were sufficient to supply the Matter for all these Rivers.

SECT. LIV. *The Disposition or Fitness of Mountains for the aforesaid Purposes, and Convictions from thence.*

Now, can this be ascribed to any other Being, than to a Wise, Powerful and Gracious GOD?

I. That we find such great Bodies as the Mountains distributed throughout the whole Earth.

II. That most of 'em are found in the highest Countries, in order to transmit these Rivers from thence to the Distance of hundreds of Leagues sometimes.

III. That the whole Superficies of the Earth is adapted thereto, which grows gradually lower on all Sides where it is washed by the Sea, as is plain from the Course of the Rivers that mostly discharge themselves therein; since every Body knows, that Water, by reason of its Weight, always runs to the lowest Places.

IV. Do we not herein see a wise Direction? that there are always so many Mountains made for this Purpose, namely, to produce such mighty Rivers as the *Rhine*, the *Danube*, the *Rhone*, the *Borysthenes*, &c. (See *Varenius's Geography*, lib. 1. cap. 16. §. 3.) and they that desire to have a larger Account thereof, and to know how the Mountains run in Ridges thro' the Earth, may meet with the same in the said *Varenius*, cap. 10. lib. 1.; as also in *Burnet's Theory of the Earth*, cap. 9. who, tho' their Heighth bears very little Proportion to the Bigness of the Globe, is yet of Opinion, that the Space which they take up, may amount to a tenth Part of the solid Land thereof: They that would form a Notion thereof, may consult the Figures which this last Author has made, tho' he uses them to a contrary Purpose, notwithstanding that he has left out several and very large Mountains, on account of the smallness of his Draught, such as the *Apennine*, and other Mountains of *Italy*, &c.

V. Now it seems still necessary, that in the Promontories, or Parts of Lands, running into the Sea, such as *Italy* itself, and others likewise, Mountains are particularly placed for this Purpose, that the Vapours arising from the Sea, should not need to be carried far over Land, before they may meet with Mountains, where they may be turned into Water, and run down again.

VI. The Islands also seemed, above all the rest, to want Mountains; forasmuch, as being shined upon by the Sun, they were hotter than the Sea-Waters wherewith they are surrounded, and therefore were not likely to receive much Rain thence. To be convinced hereof, let any one view in a Map, the aforementioned Islands of *St. Helena*, *St. Thomas*, &c. and consider,

whether it be probable that such little Plains and Spots of Land in Comparison of the circumjacent Seas, and which for the aforesaid Reasons, does so far exceed them in Heat, could entertain the least Hopes of receiving Water enough from Heaven, if GOD had not been pleased to provide for them after so particular a manner by the help of Mountains.

Now if any Body that reads the following Passages, taken from the Describers of the World, as first from *Burnet*, p. 47. *There is no solid Land either of the old or new World, or no old or new Island, but what has its Mountains.* Secondly, From *Varenius*, lib. 1. cap. 10. §. 2. *In most of the Islands, and in Promontories, the Mountains are situated so, as to run thro' the middle of 'em, and divide them into two Parts*; which he confirms by many Examples. I say, can he that reads this, continue to believe that it happen'd so by Chance? Tho' he is forced to acknowledge, that if a Man were in the highest manner concerned for the Preservation of those Islands, he could not dispose the Mountains therein after a more useful Manner, to make them serve for Watering-Pots to the Country round about them, and for collecting those Vapours, which would otherwise be scatter'd by the Winds, exactly in those Places where they would be most useful. Must not every Body see the Power and Goodness of the Great Creator and Governour of all Things, shine out most brightly, who in order to sweeten the Sea-Waters, which of themselves are salt and barren, and to distribute them throughout the Earth where-ever they may be useful, has daily forced Bodies, so considerable in Size and Strength, to contribute thereto; who has order'd the Seas, the Mountains, the Air, the Vapours, the Winds, and the Sun itself, that they might bestow these great Benefits on the Inhabitants of the Earth, not only to concur in general, but that each of them should likewise afford the most proper and most requisite of all their Faculties; so, that if the Sea had not been sufficient in its utmost Breadth and Depth, if the Mountains had not been high enough, and placed so conveniently; if the Air had not been elastical, and therefore denser below than above; if the Vapours had not been light enough; if the Winds had not been strong enough to drive them along; if the Sun had not been fixed at so just a Distance, as to yield neither too much nor too little Heat, this great Work of the Circulation of the Waters, and with it almost all Creatures had long since been at an end, and the whole Terrestrial Globe become a Wilderness.

SECT. LVI. *Rivers require a Place wherein to discharge their Waters.*

HAVING thus far traced the Rivers to their Origin, if we now contemplate their Numbers, their Largeness, and their unconceivable Quantity of Waters, which for so many Thousand Years do incessantly pass along with them for the Benefit and Happiness of all that dwell upon the Earth, every one must be convinced of the Necessity of very large and deep Spaces where these mighty Streams may rendezvous and meet with such a Receptacle, as to hinder them from overflowing the dry Ground.

Is it then by Chance, that there are prepared in the Earth such unfathomable Depths, as may contain the whole Ocean, and into which all the Ri-
vers

vers may discharge their Waters, and without which all the Power, and all the Skill that has been employed in the Frame of the World, and of the Plants and Animals upon it, would be all in vain?

SECT. LVII. *Salt preserves the Sea from Corruption.*

LET now an unhappy Atheist Contemplate with us this great Collection of the Waters, these vastly extended Seas, and say, whether in case the same did consist of nothing but fresh Waters, brought into them by the Rivers and Rains, he can even suppose, that it would have been possible for them, after having been exposed so many Ages to the Action of the Air and Sun, to have been preserved from Corruption and Stinking. Now if that had happen'd, let him consequently consider how grievously the whole Mass of Air, surrounding the Globe of the Earth, would have been infected by such a stinking Lake, and thereby produced innumerable and fatal Diseases. Let him represent to himself in this Case, all the Waters of the Sea so corrupted, that hardly any Fish could live in them. Must then again mere Chance, or something else that does not know whether or how it operates, have the Honour of what we are going to say, namely, that just at the bottom of this great Receptacle, or Pit, there grows, or is placed, such a quantity of Salt as is capable of converting all the fresh Waters that run into it, into a Pickle, and so to preserve it from Corruption, as well as to hinder the Waters in many Places from freezing; for if a Frost should happen as easily in the Sea, as it does in Rivers and fresh Waters, it would not only render the Sea many times unpassable, but, by stopping Ships in the middle of it, cause an infinite number of People to perish with Hunger?

And yet no Man can shew any Necessity, why there should be such a vast quantity of Salt found in the Sea rather than in other Places, since there are likewise Mines and Pits thereof to be met with in many Parts of the Land. Thus we read, that they dig Salt out of the Earth in *Poland*, in *Transylvania*, in *Tyrol*, in *Spain*, in *Lesser Asia*, in *Persia*, and upon the Banks of the *Caspian Sea*, which last is carried throughout all *Russia*. There is a Mountain of Salt in *Cuba*, and the Island of *Ormuz* in the *Persian Gulph*, is said to consist for the most Part of nothing but Salt; in all *Africa* they use such Mineral Salt; in *Peru* there is an unfathomable Mine of it; in the Kingdom of *Masulipatam* in *India* they dig so vast a Quantity thereof, that all the *Indians* furnish themselves from thence. See this more largely in *Varenius's Geography*, lib. i. cap. ii. §. i.

Can we then, since Salt may justly be reckon'd among the Minerals and Productions of the Earth, ascribe to Accidental and Ignorant Causes the great Benefit that hereby befalls the whole Earth, namely, that the Sea does also abound in it? Wherefore, if one were to see a quantity of Flesh put into a Vessel of Pickle, by which it is preserved from Putrefaction, would any one say, that the Salt grew there, and that the Flesh was put into it by mere Chance?

SECT. LVIII. *Bays and Gulphs of the Sea for the Reception of Rivers.*

IF this be not enough to shew the Hand of GOD to unhappy Mortals; yet an Atheist must at least acknowledge, that a great Part of the World would be render'd uninhabitable by the Inundation of Rivers, if the Earth were not washed round about by the great Sea, and, which is very wonderful, if the Sea did not transmit great Branches, Arms, or Bays, from itself into the Land, in order (besides other Uses) to receive likewise the discharged Waters of the Rivers into its Bosom, to mix therewith the Great and Salt Sea, and so to yield new Matter for Vapours, and thereby for Rain, and for continuing the Circulation of the said Rivers. From whence it comes, that this whole Structure and great Work would have been still in vain, if the Coasts adjacent to the Sea, and to these Bays and Gulphs, were not lower than the Inland Countries and Regions remote from the Sea. Now shall it be said, that a Matter of such Importance, and upon which the Preservation and Welfare of whole Nations depend, is brought to pass without a wise Design?

To give an Instance thereof: In case the mighty Arm of the Northern Ocean, which is commonly called the *East-Sea*, lying between a great Number of Countries, were not, as one may say, dug out and prepared on purpose to receive likewise all the Rivers that discharge their Waters into it, (and which *Varenius* terms, exceeding great ones) how difficult would it have been to them to have found their way into the Ocean; and how many Provinces would it have render'd uninhabitable by their Inundations, if the Streights of the *Sound*, and those of the *Great and Little Belt*, were stoppt, and all the Rivers cease falling into the said *East-Sea*?

The same would happen, if those rich and noble Coasts of that great Gulph which is commonly called the *Mediterranean*, and which Coasts are of so vast an Extent, were not so low, that the Rivers by their Weight could run down thither, and from all Parts discharge their mighty Streams, as it were into a common Drain formed for that Purpose.

For these Reasons it is, that the Passage thro' the *Dardanells* to *Constantinople* is so very difficult, on account of a Current occasion'd by the Discharge of such great Rivers as the *Danube*, the *Nieper* or *Borysthenes*, the *Tanais*, or *Don*, and others, which carry their Waters thro' these Streights. See *Robbe's Navigation*, p. 84.

Now all these Waters seem to discharge themselves finally into the great Ocean through the Streights of *Gibraltar*; and, as at the *Dardanells*, do there likewise produce a continual Current outwards.

But I was very much surpriz'd at what one of the Principal Sea-Officers of *Holland* informed me of; namely, that having often pass'd the said Streights, besides the known Currents in the *Mediterranean* Sea, which run Eastwards along the Coast of *Barbary*, and Westward on the opposite Coast, it was experimentally known to all Sea-faring People, that there was a continual Current from the Ocean through the said Streight, setting inwards. This they infer; because those that will go into the *Mediterranean*, can always pass through this Streight by Laveering or Tacking, even tho' the Wind be contrary;

trary; and yet, in the same Circumstances, can they pass from the *Mediterranean* into the Ocean, but with much Time and Difficulty.

And when I enquired of that Gentleman, what became of that vast Quantity of River-Waters which are continually discharged into the *Mediterranean*, and which seem to have no other Out-let but through the aforesaid Streights; he was pleased to answer me, that some were of Opinion, that either the Heat of the Sun exhaled those Waters from the Sea, or as others thought, that there were in the so named *Gulph of Narbonne*, or in other Places, some subterraneous Cavities at the Bottom of the Sea, whereby these Waters were discharged; at least it was experimentally known, that there is an uncommon Motion of the Sea-Waters in the said *Gulph* more than in any other Places.

Now, whether this or any thing else be the Cause why the *Mediterranean* Sea, which on the East-side, and all round, does perpetually receive the Waters of such great Rivers, and on the West-side those of the Ocean, has not in so many Ages been so far filled therewith, as to overflow the adjacent Countries: This is certainly true, that the Divine Providence does herein display itself after a wonderful manner, whereby God has given a convincing and ocular Demonstration, that He will not be bound by any necessary Laws of Nature, but is able to perform all things according to his own good Pleasure, producing in such a little Corner of the World, as is the Distance of the Streights of the *Dardanells* from those of *Gibraltar*, such an amazing Work as the making Place for the Discharge of those mighty Rivers, after two such different and unaccountable Ways. Numberless would be the Wonders that might be produced upon this occasion from the Natural Histories of the Seas and other Waters; we shall therefore refer our Readers to those that have given Relations and Descriptions of the Sea and Land, all which if we were to repeat, would be an endless Work.

SECT. LIX. *The Uses of the Sea.*

BUT because we have been prolix enough upon this Subject, let the Atheist go farther with us, and observe, how the Sea does not only surround the whole Earth, in order, as has been said before, to receive into its Bosom the Rivers and fresh Waters, and preserve them from Corruption by its Salts, till they become useful again, but likewise, how the said Seas are the only Means by which Commerce and Traffick can be carried on; and each Part of the Globe, that has the Advantage of lying near them can enjoy, by the help of Shipping, all the Advantages and Conveniences of the most inland Countries: So that the Great Creator has vouchsafed not only to take care of those that lye near the Sea, but likewise of all that live in the very Heart of the Continent, by the means of Rivers, and by the imbaying or breaking of the Ocean many Leagues up within the Continents themselves; Instances of which have been given in the East and Mediterranean Seas.

Let us produce another Example: If *Holland*, which has hitherto been so signally Blessed by God, but which is surrounded with with unfruitful Countries and barren Heaths, had been obliged to have fed its Inhabitants with
nothing

nothing but what itself produced, perhaps there would not have been a more miserable and defective Nation in all *Europe*: Whereas now, by the help of the Sea only, every thing that the Old or New World can afford, either for Necessity, Convenience, or Ornament, are brought hither in great abundance. Can then a *Dutchman* ever look upon the Sea without thinking at the same time, how much he is indebted to Him that made it?

SECT. LX. *The Force of the Sea in bearing Burdens; and Convictions from thence.*

WERE there no Sea, what vast Machines should we stand in need of? What a Strength of an unexpressible Number of Men and Beasts would there be wanting to bring home to us those mighty Burdens which an *Indian* or an East-Country Fleet does now supply? the more, because the Merchants must then have been obliged to pass thro' the Countries of other People, it may be of Enemies, or of such Nations, who, like the *Arabians*, live upon Plunder; insomuch, that besides the Numbers of Men, they would likewise be forced, for their own Defence, to carry with them great Trains of Artillery, and all other kinds of Ammunition and Provision: Whereas now these heavy Ships, containing all these great Burdens, are so easily born by the Sea, and driven forwards by small Blasts of Wind, and very long Voyages performed with much Conveniency and little Time.

If an Atheist should still maintain, that all this is so disposed without any Wisdom, let him contemplate a well-equipp'd Man of War, or even an *East-India* Ship, and let him be ask'd, what Means could possibly have been invented to have put a Machine of so great a Weight as such a Ship, with all its Lading and Cannon, into such a Condition, as to cause it to move with a very small Force, without the Assistance of Water, or any other liquid Matter? The only Answer, if he were a skillful Mathematician, that he should be able to give, would be; That such a Ship must be put into a sufficient Equilibrium, in which case the least additional Force would be able to move it; just as if it were hanged by a Chain or Rope to a Crane, or to one Arm of a Balance, which had an equal Weight fastened on the other Arm; or after such other manner as a Mechanick could propose to himself. But then it is no less certain, that among all the known Materials, none could be found sufficiently strong to serve for Instruments to such Experiments; much less could they frame any Idea of bringing a Ship from the *Indies* in such a manner.

Now in these Circumstances, if any Man should tell him, that he knew a way how to carry so vast a Burden some hundreds of Leagues, and to keep it in a constant Equilibrium, without ever changing its State, so as to be able to move it with a very little Force which way he pleased, according to all the Points of the Compass; would he dare to answer, that such a thing could be performed without a wise Contrivance?

SECT. LXI. *The same Arguments enforced.*

THIS would be the Time to shew the unexpressible Footsteps of an adorable Creator more clearly than at Noon-Day; and to say something of those Laws of *Hydrostatics*, which are more wonder'd at by every one, than as yet understood,

understood, in relation to their way of working; but we shall do this more largely in its proper Place; and we beg those that read it, to apply what we there say, to the Powers of the Sea, to the end, that they may be more fully convinced, even with Astonishment, of the Wisdom and Power of the Great Creator.

To say one word or two of it here; Can one judge, that there is no Knowledge or Contrivance required to raise up one of the greatest Men of War by the help of a few Tuns of Water, which for Weight are by no means comparable to it? And yet it is plain, that this may be done, if such a Ship, drawing 20 Foot of Water, stood upon dry Ground, and that there were made about it a Dock or Sluice of about 21 Foot in Depth, in such a manner that there should not remain more than the Breadth of half a Foot, or a good deal less, between the said Ship and Dock. For in case this Interstice between the Ship and the Dock (which being about half a Foot more or less in Breadth, would contain very little Water) were filled up to the Top with Sea-Water, every body knows, that the aforesaid small quantity of Water being so disposed, would raise up and put into Motion, so prodigious a Weight as that of the whole Ship.

This must not be ascribed to the Lightness of the Wood alone, as if the Water had but a small Share therein: Forasmuch as we hope hereafter experimentally to prove the contrary, when we come to treat about the Laws of *Hydrostatics*.

Can then any rational Creature be so deplorably blind, as not to see in this mighty Violence of so surprizing a Force as is here exerted by the Water, and which is yet so absolutely necessary to put any one Ship in a Capacity of sailing; I say, as not to be convinced of the Wisdom of the Creator? Can a meer and stupid Chance ever subject such a Matter as Water, ignorant of its own Nature and of every thing besides, so accurately and nicely to the Laws of Mathematicks; insomuch, that before it recedes from them in the least point, it acts unconceivable Wonders? But more of this hereafter.

Especially when a Man sees, at the Arrival of the Fleets, a great number of Ships lying almost close to one another before the City of *Amsterdam*, and how such a small quantity of Water so easily bears this prodigious Burden, without appearing to suffer any Violence, and keeping them in an *Equilibrium* by an incomparably smaller Force, makes them capable of Motion on every side. Further, when he reflects with himself, that if the said Water were by any means drawn from under them, and that all those Ships, fat dry, what an Apparatus, what Machines, what a Force of numberless Men and Horses would be wanted to move them only one Foot from their Place. Would it not seem a most inscrutable thing to him, that an ignorant passive Matter, such as Water, could so easily bear such an amazing Weight on its back, and waft it along by a gentle Current only, so many hundreds of Leagues?

I have dwelt somewhat the longer upon this Subject, because if ever the terrible Power and adorable Wisdom of that GOD who orders all things in the World, appears in its greatest Lustre, it must be confessed to do so in the present Case; and it seems to me, that if this astonishing Force of the Water

(by which it holds such immense Weights, in its hand as it were, and offers to Men to bring them any way according to their Will) if it be but well consider'd by a doubting Philosopher, is alone sufficient to prove irrefragably the Presence of a G O D who is dreadful in his Power, and great in his Wisdom and Goodness; I say, all this would appear even to a Demonstration, if he would but divest himself of that careless manner in which Custom makes them look upon all, even the greatest things, without Attention; and if they could rightly contemplate so stupendous a Work.

SECT. LXII. *The Fishes of the Sea.*

CAN a Man now that has any thing of Gratitude in him, persuade himself, that he has no Obligations to that G O D, who has surrounded the whole inhabitable Earth with these Waters, and holds them every where in a continual Readiness, that their mighty Strength may be serviceable to Mankind? If he can, let him go one step farther with us, and contemplate the Depths of the Sea, which in so many Places is unfathomable. It was not sufficient for the Great Creator to preserve the Ocean in such a State, for all the abovemention'd Purposes; but that this great Space of Waters should not be without further Uses, and to the End, that the Hand of its adorable Maker might be manifested as well by the deepest Cavities as by the vastly extended Superficies thereof, He has been graciously pleased to furnish it with such innumerable Kinds of Fishes, and other Marine Creatures, by the multitude of which so many Men are continually fed; insomuch that where no Bread can be procured, but with great Trouble and Charge, the same being dried, does likewise supply the Want thereof. Not to mention here the inexpressible Variety of Fishes, by which the Appetite and Palates of so many Eaters are gratified; will an Atheist dare to mention, that the Sea likewise, in this case, with all its Fishes, were made without Design? Whereas he himself, and all Land Creatures, could not be able to remain a quarter of an Hour under Water without dying: Is there then no Knowledge required to form so many Creatures after such a manner as to be able not only to live always in the Water, and as other Creatures find their support in the Air, they, on the contrary, get their whole Subsistence in the Water, but likewise bring forth their Young there in so great abundance? Further, let us consider how much the Structure of the Eyes of Fishes differ from that of the Land-Creatures, the first being adapted only to see in Water, the other in the Air. Let him also consider the Shape and Form of Fishes, where he will plainly discover all those Qualities that are requisite to support them in Water. And since some of them can live only in salt and others in fresh Water, let him observe with wonder, that Care is taken for the first by the Sea; and for the last, by Rivers and fresh inland Waters. And if he desires to be further informed of the Relation which the Fishes and Water have mutually to one another, let him turn to what is said here below concerning the Fishes, and compare it with this Dissertation about the Sea.

SECT. LXIII. *Convictions from the foregoing Observations.*

IF now, after having seen and understood all this, any one can pretend still to remain unconvinced of the Wisdom of a Being which has form'd it all, let him only examine himself, whether he be really disposed or not to be convinced; if not, we can do no more than only to pity his most miserable Condition; but if, contrary to his own Will and sincere Endeavours, he perceives that he is not satisfied, there seems no other wholsomer Counsel for him, than most humbly to implore that GOD, by whom he desires to be convinced, that he would vouchsafe to bless those Studies which he employs in contemplating his Creatures, and enable him to prove his Existence by his Works, with the same Acquiescence and Conviction which he finds in himself, when by seeing a curious piece of Workmanship, such as a well contrived Watch, a convenient House, a Ship with all its Tackling, &c. he concludes, that these things were made by a skilful Artificer, for certain wise Ends. Which Method, to my Knowledge, GOD was pleased to sanctify to a great, but unhappy Philosopher, in his last and Death-bed Sickness.

SECT. LXIV. *The Circulation of the Waters does likewise preserve the Land from overflowing.*

TO add something farther, which seems to give such as are not entirely hardened, an irrefragable Proof of a GOD that rules the Sea; Can any one see, without the utmost Amazement, that so great, so extended a Space, in which so dreadful a quantity of Waters is contained, as the Ocean, does not overflow the dry Land, and especially where it is so low, as that of *Holland*; since there is such a Concurrence of Circumstances that seem to render it unavoidable, unless a greater Power and Wisdom had intervened.

To shew this, let any Man tell us how it is possible, that such an innumerable Company of Rivers, and among them, such great ones as *Varenus* mentions in his Account of Rivers, §. 27. do Day and Night continually discharge into the Sea such an unconceivable Quantity of Waters, and still do the same so many Ages without ceasing, and yet not fill the Sea, nor force it to exceed its Bounds, and overflow the Land.

This would be unintelligible to every one, were it not that all these Waters did constantly observe the Circulation we have shewn before; whereby those Waters that are brought into the Sea by the Rivers, and increase the same, are again attracted by the Heat of the Sun, and do rise up into the Air under the Form of Vapours, and there they, or at least great part of them are collected upon the Tops of Mountains, or descend again in Rains, and become little Brooks, which by their Union, make up the same Rivers that carried them into the Sea. Thus performing their continual Circulation from the Land to the Sea, and from the Sea thro' the Air into the Land again.

SECT. LXV. *Convictions from the foregoing Observations.*

NOW let me ask an Atheist, whether besides all that we have already said about the *Sea*, he imagines that these things have come to pass without any Direction; and that all that contributes to this great Circulation, has acquired so opposite a Constitution without a determined Purpose? Why then is not the *Sea* quite exhaled, and dried up? Why is it not increased by the *Rivers*? Either of which would produce the certain Destruction and Ruin of the whole Earth. And whence comes it that the *Sun* has continued for so many Ages in such an exact Degree of Heat, as to leave in the *Sea* always about the same quantity of Water, without our being able to discover any remarkable Diminution, or Augmentation thereof? And after many of the like Questions, which one might easily put on this Occasion, can any reasonable Man believe that a blind and ignorant Cause, a meer Chance, (which may every Minute act after a different manner) has had the Direction of it? and which has been able to confine such an infinite Host of so many Millions of watery Particles to such fixt and so necessary Laws, for the good of those that inhabit this Globe, without the least Deviation; and to make those Particles always return to the *Sea* from whence they came?

SECT. LXVI. *The Dykes or Banks of Holland.*

IF any one desires to see a further Proof of the manifest Government and Direction of the Great Creator, let him pass along the Dykes of *North-Holland*, and there take notice in how many Places the Waters of the *Zuider-Sea* are higher than the Lands that lie within the said Dykes. Let him farther contemplate the Smallness of these Dykes, in comparison of the great Extent of *Sea*, which lies and presses upon them; Let him observe the amazing Power and Strength of the *Sea*, by which, tho' cover'd with Ships, it so easily bears the unexpressible Burden, and upon the least stirring of its Waves, can move and lift them up. Would he, if he did not know those Laws to which the Great Ruler has subjected these watry Desarts, would he not consider it as a continual and unconceivable Miracle, that those Dykes, so small and slender in respect to the Waters that press upon them, have not been overturned and carried away long ago by the Weight thereof, and the adjacent Land turned into *Sea*: At least it appears from hence, that there is need of more than humane Assistance to preserve such a Country from Inundations.

For instance; Let us suppose AB (*Tab XV. Fig. 2.*) to be the Breadth or Extent of the aforesaid *Zuider-Sea*, and if you please too, cover'd with Ships, which, by their prodigious Weight, do press the Waters forward on all Sides; Let AC and BD, be the Dykes (which we only represent here in their Height by a Line) which hinder the Water from overflowing the Lands IK, that lie behind them. Now if one draws the Line CB, 'tis plain, that all the Waters at ACB, would press against the Dyke AC; in case the Waters observed the same Laws in gravitating as solid Bodies do. Now, let any one imagine this whole Body ABC, to be cover'd with Wood,

and the whole Superficies thereof, A B, with tall and well equip'd Ships instead of Water, as has been here supposed. Now, if this great and heavy Body could slide downwards so smoothly, and without any Friction or Resistance, along the Oblique Line B C, as the Water can do, and could press after the same manner upon the Dyke A C, one need not ask, whether the Dyke could stand against it only one Hour. Now, since Water is uncontestably heavier than Wood, 'tis plain, that the still-standing Sea would act with greater Violence against the said Dyke than the Wood A B C, in case the Water should operate according to its Weight, after the same manner as the said great Body: The Consequence of which would be, that no Land in the World, which lay lower than the Sea, could be defended against it by any Dykes.

Now let the most subtil Atheist inform us after what manner he can deduce this Disposition of the Particles of Water, not only upon the Principle of a fortuitous Concourse of the Parts, or from ignorant Laws, but even from his own presumptuous Wisdom and Philosophy; as also after what manner Water, tho' it preserves its Gravity, shall yet be so restrain'd as to its Pressure, as to suffer itself to be contain'd within such narrow Limits as are our Dykes.

To account for this Difficulty in some measure here (since we shall speak more fully of it hereafter in its proper Place) is it without Wisdom, that the whole Sea A B C D (*Tab. XV. Fig. 2.*) cover'd with this vast Weight of so many great Ships, and of the Breadth of so many Leagues, does not press stronger against the Dyke A C, than the small but equally deep Ditch A E would do, which is no broader than a Rod, and a good deal less?

Wherefore, tho' the Dyke A C, consisted only of thin Glass, the whole Sea A B C D, would not be able to break it with all its Pressure, if there were only behind the said Dyke, at G H C A, a little Water, no broader than the length of a Rod or Perch, but as deep as the Sea.

Now, that this is true, they that understand Hydrostatics know very well: We shall also shew it more largely hereafter. And the same is the only Cause why the whole Sea, cover'd with thousands of Ships, if it be calm, and not too deep (since it is by the Depth only, and not Breadth, that its Pressure is increased) is often bridled by a slight Dyke, and prevented from overflowing so many Countries, and drowning Men and Beasts.

SECT. LXVII. *Sand stops the Sea, and proceeds from it.*

BUT now if any one goes farther, and has ever contemplated this dreadful Abyss in its wild Motions, when excited by Storms, or its Waves rising to incredible Heights, and threatening to inundate and swallow the dry Land: Can he then think it is by Chance, that the mad Waves of this terrible Heap of Waters are to this Day contained within its Bounds? And he that has ever seriously and earnestly reflected upon the whole, must he not entirely justify the Discourse of the Great Creator of all Things, when he sharply rebukes the careless *Israelites* for their Blindness and Dullness in the

following manner, by the Prophet *Jeremiah*, ch. v. ver. 21, 22. *Hear now this, O foolish People, and without Understanding, which have Eyes and see not, which have Ears and hear not, fear ye not me? saith the Lord: Will ye not tremble at my Presence, which have placed the Sand for the Bound of the Sea, by a perpetual Decree that it cannot pass it; and tho' the Waves thereof toss themselves, yet can they not prevail; tho' they roar, yet can they not pass over it.*

Shew any one that has seen a stormy Sea rolling its Waves in its full Course, a handful of Sand, and tell him that such small, such contemptible Bodies, which one may blow away with one's Mouth, can restrain the Rage of those watty Mountains; will he not look upon it as a Wonder? But tell him moreover, that the Sea itself does, according to all Probability, produce that Sand, and thereby becomes itself a Bridle to its own fearful Powers, according to the above-mention'd Experiment of *Messieurs Hook and Plot*, where it is shewn, that by the Evaporation of Salt-Water (which is continually performed by the Heat of the Sun upon the Sea) a great Quantity of Sand is produced. Can he likewise think that a blind and ignorant Nature has bestowed this Property upon the Salt-Water of the Sea, and thereby only preserved such flourishing Kingdoms and so many Provinces from Inundations, with casting up whole Mountains of Sand out of the Sea, in Places that otherwise, by reason of their Flatness and Lowness, might daily expect to be swallowed up? Can he look upon the double Sand-banks placed along the Coasts, which are like so many Walls and Bulwarks against the IncurSION of this all-destroying Sea-Enemy? Can he observe the oblique Ascent of the Shoar, in order to break the Force of the Sea, or the Height of the Downs that lie behind, without being obliged to own, that a great and adorable Engineer has vouchsafed thereby to fortifie this Country against an Invader, powerful beyond Conception, and which assaults them continually? The rather, because one cannot imagine how it should be possible that such loose Heaps of Sand are not entirely scatter'd by the Winds, when we see so often such great Quantities thereof raised up and carried thro' the Air. Again, will any one say, that it is by meer Chance, that in these dry and barren Sands (which otherwise are hardly capable to produce any Plant) certain Herbs or Weeds do not only grow, but are likewise proper to be transplanted, by Means of which these Sand-banks are defended against the scattering Winds, and the Downs brought and continued in their Places where they can be most serviceable?

SECT. LXVIII. *The Sea-Weed the Support of Dykes.*

IN other Places, where the Sand is not in so great Plenty as in the *Zuider-Sea*, which is supposed to be formed by an Inundation from the Ocean, and which is only bounded by Dykes; Experience shews, that no better can be found for the making thereof, than that Sea-Weed which we call *Wier*. Now can any Body imagine that the *Hollanders*, in this Case, speak without Reason or Grounds, when they fetch from thence a Proof of a GOD that preserves their Country? Forasmuch as they see, that this Weed

Weed is produced even by the Sea, in great abundance, and the Dykes thereof are maintained by it.

SECT. LXIX. *The English Channel preserves Holland.*

YET more; forasmuch as all this does hardly seem sufficient to secure our Low-Countries from being buried under the Waters of the great Ocean, can any one imagine, that it is ordered by Chance that the Promontory of France, and that great and noble Island of *Great Britain* make between 'em a Streight or Channel, which is broad enough for a Fleet of Ships to pass thro', and yet narrow enough to hinder this dreadful Ocean, when it ascends in its Flux, from discharging with full Strength his watry Mountains upon the Coast of *Holland*: Since either by wanting too much Time to pass thro' the Channel, it is carried back by a seasonable Ebbing, or, as others think, because the North-Sea growing continually wider on this Side, the Waters that flow thro' the Channel cannot continue at such a Height. Accordingly, Experience teaches us, that for this last Reason the Tide of Flood runs five or six times as high at *Calais* as in the *North-Sea*; which is observed by Mr. *Hartsoeker*, in his Treatise of Natural Philosophy.

SECT. LXX. *The Cause of Ebbing and Flowing omitted.*

WE shall pass by the famous and great Motion of the Sea in its Flux and Reflux, or Ebbing or Flowing, as well as others that are not less wonderful; forasmuch, as the Causes thereof seem to be kept among the inscrutable Secrets of the Creator; referring those that desire farther Informations to the Opinion of the great Naturalists, some of which seem to carry along with them a great deal of Probability.

This is certain, that the Waters of the Sea under the Moon, or nearly under it, do on both sides of the Globe raise an exceeding great and convex Mountain, which daily surrounds the Earth. Now, that this cannot happen without disturbing the Sea, even in its deepest Cavities and Abysses, is plain enough.

Mr. *Mariotte* has shewn (in his Book *Du Mouvement des Eaux*, p. 217, &c.) experimentally, that in running Waters, unless some particular Occasion intervenes, the Water at or near the upper Superficies, runs much swifter than that in the middle, or at the bottom; for which reason, in great Depths of the Sea, notwithstanding the Currents and Motions that may prevail at Top, it is credible, that the lowest Waters are quite still, or move but very little; so that the same having stagnated for so many Ages, might easily be corrupted.

Now, whether the Great Ruler does not likewise make use of those Motions and Tossing of the Waves, to preserve the Sea Water from Corruption, even to the very Bottom of them, to keep the Fishes and other Creatures alive, and the Air itself pure and sweet, which might otherwise be infected thereby, we leave to the Judgment of the Learned: At least 'tis well enough known, how very useful the Flowing and Ebbing of the Sea is to Mariners, particularly, when they sail out or into their Havens, where otherwise there might

might be great Danger. You will see below, in *Contemplation XXV.* something more relating to this great Phænomenon.

SECT. LXXI. *Water bestowed in such great abundance, and for so many Ages gratis to Living Creatures.*

BEFORE we quite leave this Subject, let us in the last Place beseech all unhappy Philosophers seriously to consider, that this Water, which brings along with it so great and so many Advantages, is to be found in such great Plenty, and to be procured by those that want it, almost in all Places, for nothing. Cannot we see herein the Goodness of the Giver! And he that knows not how sufficiently to value the Benefit, let him only represent to himself the exceeding Trouble and Concern that all Men are in when they apprehend a Scarcity thereof, as it happens sometimes in besieged Towns, and to the Ship's Company in a long Voyage. But besides this, does not the Wisdom of a Divine Direction appear herein, that this Water is always abounding, and never fails, notwithstanding that we might justly fear, that considering all the Occasions whereby the Water may be either lessen'd or corrupted, every living Creature would perish with Thirst?

How many Years, yea Ages, has this Water been moved by the Winds? been rolled along hard Beds? dashed against Rocks? used in extinguishing Fire? served for Drink to so many Creatures? drawn up into the Clouds? fallen down into Rains, and, by reason of its Weight, driven violently down Walls, Houses, Mountains, Rocks, and other hard Bodies? been congealed into Ice, Hail and Snow? and finally been moved and handled in the roughest Manner by different Powers? And may not every one then, with great Probability suppose that the Water, after having undergone all that is above-mention'd for so many thousand Years, should be worn out and have changed its Figure, or, which is the same thing, its Properties. So that any Body who knows how much all things are worn by a continual Use, by which they are certainly render'd less fit for Motion, could hardly be induced to believe, that one and the same Substance, after having withstood so many and so great Shocks, between five and six Thousand Years, should be able to preserve the same Figure. Notwithstanding which, we are taught by daily Experience, that the Waters of the Sea, of Rivers, and of Rains, have remained always unchanged, and preserved their Nature and Properties. Can we not then observe herein a Government, a Providence, not only surpassing all humane Power, but even all Opinions and Arguments? And is not the mighty Hand of a Great Preserver visible enough to all that will consider this without Prejudice?

Now if any Body should object against this, that Water as well as all other Substances, does undergo an Attrition, but that there is continually as much new Water produced by other Causes as that which is worn away and otherwise wasted; yet that will not lessen the Wonder, nor in the least enervate this Proof: For if it be allowed, will there then be no want of a wise and powerful Direction to substitute continually an equal Quantity of Water to that which is lost by Attrition, and without which the whole Earth would fall

fall into Disorder? And can any Body, upon such an Hypothesis, pretend that it comes to pass by Chance or ignorant Causes, that there is just as much Water produced as was worn away, or consumed, by the various Uses thereof? Why then is not there more produced than was lost? And why are not the Rivers, in so many thousand Years, increased to such a degree as to overflow the most Part of the dry Land? Or, on the other Side, why is not the Water diminished? Why is not there more corrupted or wasted than is produced? And why are not the Seas, and all the Collections of Waters, evaporated or dried up in so many Ages? Moreover, in case the Particles of Water were anywise angular or oval, why are they not become quite round, by a perpetual Attrition against each other for so long a time, that being the last Figure assumed by most Bodies after the Attrition of their Angles? And if these Particles are globular, why are they not entirely crumbled to Atoms by this incessant rubbing, and wearing, and striking against each other, or, as some Philosophers fancy, turn thereby into the Substance of Fire? At least, if the Essence of Water consists in a determinate Figure of its Parts, how can such an Attrition happen without any Change in its Properties at the same time that the Figure thereof is changed? And why is not Water, for these Reasons, represented to us now under a quite different Appearance from what it was several Ages ago? If we now add to what has been already said, and if we consider how much Water (according to the abovementioned Experiment of Mr. Boyle) can and will be turned into Earth by a continual Distillation caused by the Sun and the subterraneous Fires; how much is fixed and incorporated with, or converted into thousands of Plants; how much is used in the Composition of the Bodies and Humours of such an infinite Number of Creatures; might we not with great Reason judge, that this continuing for thousands of Years, and the great number of things which are made up of Water in a great measure, being likewise consider'd, it must have been long since exceedingly diminished, if it had not quite failed. Nevertheless, we see that this Water remains in the Quantity that is necessary for all our Uses.

Now let a Philosopher, of what Sect soever he be, shew us whether this can happen and continue unvariably (which alone is a Wonder) without the Direction of a superiour Power and Wisdom: For if the Care of a supreme Director ever appear'd glaringly, it is certainly in this Case, in which he will not suffer his Creatures to want what is so necessary for their Preservation. And why does not he argue justly, who thinks that at every Draught we take for extinguishing our Thirst (which, whatever you please to call it, consists of or is derived mostly from Water) that we are bound to return our Thanks to the Giver of this so wonderful, so agreeable, and so useful a Blessing, which He deals out with so much Wisdom for the Preservation of all that live; to say nothing of our own Impotence, as big as we appear in our own Eyes, who can't produce one single Drop of this Element. Let then the most presumptuous Atheist tell us how he, with all his imaginary Wisdom, can prevent the entire Desolation of this Globe, and the certain and unavoidable Death of every thing that breaths: And in case he finds himself unable to perform this small Matter, can he still imagine that he is only beholden to a meer and stupid

pid Chance, to Causes ignorant of their own Effects, and operating without Knowledge or Wisdom, not only for the Discovery, but also for the bountiful Participation of this most unvaluable Present; and that those, as ignorant as they are, have been able to suppetitate a Means of furnishing the World with Water?

If now the very Atheists themselves shall own it to be unreasonable to think thus of Matters, as in truth they must, if they pretend to maintain their Title to Wisdom, what need have we of more Arguments to confute them?



CONTEMPLATION XX.

Of the Earth.

SECT. I. *Transition to the Earth.*

NOW, if after having contemplated the Air and the Water, we pass on to the EARTH, we cannot help affirming, that whosoever shall maintain that all the Qualities and Properties that are to be found therein, are to be only ascribed to mere Chance, or ignorant Laws of Nature, operating without Design, must cleave to a wonderful kind of Philosophy, if he does not affirm the same against the Contradictions of his own Conscience.

It is true, that the Earth, as such, and so long as it remains in its natural State, cannot serve either for Meat or Drink to Men and Beasts; but however, that every thing living is supported and preserved by its Fruits, is plainly taught us by Experience.

SECT. II. *The Earth produces Grass, Corn, &c.*

LET an Atheist, to fetch no Proofs from the Depth of Nature, cast his Eyes, *First*, upon that common Herb, that contemptible Grass which springs so abundantly out of the Earth, and feeds such a number of Cattle: And, *Secondly*, upon the various Kinds of Corn, whereby such Numbers of Men are likewise nourished; and then let him consider with himself, whether it be by Chance that the first grows of its own accord out of the Earth in such an infinite number of Places, and serves for Provision to the Cattle. And in case there were not such a Disposition in the Earth, that it produces Grass in so vast a Quantity almost every where, without the least Labour, or without any Cultivation, what possible Means could have been invented for the nourishing and preserving alive so many Millions of living Creatures, which in themselves have not the least Fitness for tilling and sowing the Earth?

SECT. III. *Beasts are Kitchens for the Grass.*

FURTHERMORE, since he cannot deny neither, that tho' the whole World were full of Grass, yet all Mankind might perish with Hunger, since sad Experience has frequently taught us, in barren Years, that no body can live of Grass; will he again say, that this is likewise accidental, and without a wise Direction, that the Earth is adapted to produce Corn and other things, which serve Mankind for Food? And since Grass of itself is not fit for that purpose, that by being eaten of Beasts, it should be changed into their own Substance, and so become useful not only for Food, but even for Dainties too; insomuch, that we may look upon Oxen, Sheep, and all other Creatures, that are taken by Men for Food, as so many living and walking Kitchens, in which is prepared the otherwise unprofitable Grass, which thereby becomes good, wholesome, and palatable Food.

SECT. IV. *Convictions from the foregoing Observations.*

AND whereas the greatest Philosopher, with all his Wisdom, cannot produce one single Grain of Wheat, or the smallest Leaf of Grass out of the Earth, nor even inform us with Truth, how they grow and subsist, and much less, what is the Cause that Grass serves for Food to the Cattle, and yet can nourish no Man before it becomes Milk or Flesh by the Changes it undergoes in their Bodies: Can he then persist in such an Opinion, that it is without any Design, or Knowledge, of a Providential Being, that there is this Analogy found in Beasts and Grass, in Men and Corn, by which both are supported; and that it is one and the same Earth produces them both?

If this can be maintained, I don't see why one may not say, with as great an Appearance of Reason, that a Lock and the Key that is made and adapted to it, are both of them produced by the same Iron, without Understanding and without Design.

Let those that would make use of such Evasions, consider only how many other sorts of Herbs daily come out of the Earth; and since there are produced Thorns and Thistles (to say nothing of Poisonous Herbs) as well as Fodder for Beasts, and Bread for Men; let him shew us the least reason, why the first, namely Grass, grows almost every where without any Trouble even in the most solitary Wildernesses, where it feeds Harts and Hinds, and other Grass-eating Creatures, in great abundance; whereas, on the contrary, to produce Corn and humane Food from the Earth, there is required so much Plowing, Harrowing, Sowing, Weeding, Mowing, and so much other painful Toiling?

This has frequently put me in mind of the Accomplishment of that Threat which GOD pronounced to Man, at the Beginning of the World; *Gen. iii. 17, 18, 19. Unto Adam he said, because thou hast hearkened unto the Voice of thy Wife, and hast eaten of the Tree of which I commanded thee, saying, thou shalt not eat of it: Cursed is the Ground for thy sake; in sorrow shalt thou eat of it all the Days of thy Life. Thorns also and Thistles shall it bring forth to thee: and thou shalt eat the Herb of the Field. In the sweat of thy Face shalt thou eat Bread till thou return unto*

the Ground; for out of it wast thou taken; for Dust thou art, and unto Dust shalt thou return. Now all this is true by sad Experience; by which we are taught how much Pains are required to clear the Ground from Thorns and Thistles, that it may be fitted for the Support of Mankind.

SECT. V. *Different Productions and Powers from the same Earth.*

STRONGER Demonstrations of a Wise and Gracious GOD no Man can justly require, than that which the Earth may teach every one who Contemplates the Properties thereof. Nor is there any deep Philosophy necessary for such Convictions.

Bring a Man only into Meadows where the Grass springs out of the Earth for the Cattle; or into plowed Lands, where the Corn grows for Mankind; into Gardens, where one sees such noble and refreshing Fruits; into Woods, where one finds innumerable Trees which furnish Materials for Building; into a Kitchen and Physick-Garden, where are a number of Plants and Herbs, some of which serve for Food, others for Medicines in the Disorders and Distempers of our Bodies, and for other Uses; into Flower-Gardens, where there appears an infinite Quantity of the most charming Colours and Smells of various Powers and Effects. Then ask him, Whether he or any Body else, ever understood the Manner in which all this is produced in the Earth; and whether those can be thought to argue so improperly, who maintain that all this seems to them one continual Miracle and Demonstration of a terrible, but no less bountiful GOD, who, from one and the same Earth, is able to produce such an unconceivable Variety of Plants. Let them freely maintain, pursuant to late Discoveries and Experiments, that there are Seeds, Plants and Stamina in all Seeds and Buds, which are expanded and augmented by additional Juices: But how will he be able to deduce the Diversity of Powers from the same Earth, after such a manner as may give entire Satisfaction to the Learned?

SECT. VI. *Convictions from the foregoing Observations.*

NOW if there should be shewn to one of these unhappy Philosophers, who had never seen any Earth, a piece of black and uncomely Matter, would he not, upon contemplating all the before-mentioned Operations and Effects, take it for one of the most wonderful things in the World? And further, if some Body that were the only Possessor of this Earth, should declare, that he had thus disposed it by his Wisdom, and would generously present him with a small Parcel thereof, would he not reckon this noble Gift among his most valuable Rarities, and shew it to other curious Persons as a very precious thing? And if it should so happen, that one of those to whom he should shew it, should say, that he did not think the Person that had prepared it, to be wise or knowing; and, that altho' he had made such a Mixture, it could not be ascribed to his Skill or Judgment, but only by mere Chance, or some other ignorant Cause; would not even this Philosopher declare, that great Wrong and Injustice was done to the Maker of such a prolifick Matter; and that from the Aptitude and Property which this Earth has to produce so great a diversity of Plants, an irrefragable Proof may be drawn, that he who invented and compounded

compounded such a Mixture, must have had not only a particular Knowledge thereof, but likewise of all the Herbs and Plants which such a Matter produced; and consequently must be wiser than Thousands of other Men, who, how learned soever they may be, if once the Earth should fail, could never inform us whereof it properly consisted, and wherein lay its Power or Faculty to produce all Sorts of Plants.

Let a deplorable Atheist himself make the further Application to what has been said: And forasmuch as he will find that this Earth is disposed in so great an abundance, and for the service of all Men throughout the whole inhabitable World; far from being any Want or Defect thereof, this noble miraculous Matter is trod under foot by Men and Beasts, and serves for Ways to Travellers: And whereas we should have acknowledged an unconceivable Wisdom in the Preparation and Disposition thereof, if there had been but a very small Quantity of it in the World; shall we now doubt of the Wisdom and Goodness of the Great Creator, only because he has been so bountiful and liberal thereof, and has communicated this wonderful Gift in so great an abundance to Mankind.

To say a little more upon the same Subject: Whereas every one would stand amaz'd if he had seen but one Tulip, one Rose, or one Lilly only growing out of such contemptible Matter as the Earth appears to be, and could never be tired in praising the Wisdom of Him who had found out the way of producing those noble Flowers; shall we therefore now be more backward in acknowledging the Great Creator in his Perfections, because instead of disclosing to us one Wonder in one Plant, we daily discover a thousand Wonders in as many Plants.

I have often consider'd with Wonder, the Obdurateness and Insensibility to which the Custom of continually enjoying a thing is able to bring Men's Minds; that can make an unhappy Atheist believe, that such innumerable Trees, innumerable Flowers, and innumerable Plants are produced by meer Chance, at least without Wisdom; whereas he must own, even against his Will, that the Man who could but find out the way of making one only Julyflower or Tulip spring out of its Onion or Bulb, and the Structure of it, was endow'd with a wonderful Understanding, and great Insight in the Laws of Nature.

I leave it now to their own selves, whether such a Behaviour can be called reasonable; and beg them, in order to be in some measure affected herewith, that they would contemplate the Earth and its Productions, not slightly and after the usual manner, but single out any Herb, Flower, or Tree; and then taking in their Hands some of that Earth in which they grew, compare it with the said Herb, Flower, or Tree; and finally fixing their Thoughts upon one of those particular Objects, ask themselves, how many thousand several kind of Plants spring out of the said Earth? and I don't think, at least I don't hope, that they will consider it otherwise than as an unconceivable Wonder of Wisdom. And since neither they, nor any one whom they know, can produce one single Clod of Earth, no bigger than a Man's Fist, with all their Skill, and that if this Earth were not bestow'd on them

with a bountiful Hand for their use, all things living would perish with Hunger, ought not this Favour of the great Benefactor to stir them up to Thankfulness? What then is able to do it? Certainly, if it had not been a gracious and powerful GOD that made this World with a wise Design, and who still preserves it in so proper a State, why does not this Globe of Earth consist in all its Parts, as well as in some, of barren Sands and Rocks? And why are Men and Beasts (as has been formerly observ'd) of just such a Structure, as to be fed and preserv'd by the Produce of the Earth, and hardly by any other thing besides? If a Man be to be convinced, one would think it impossible for him to contemplate all these things without seeing the Folly and Unreasonableness of Atheism.

SECT. VII. *Earth is never consumed, nor becomes entirely barren.*

WHEREAS now this Earth feeds every Creature, such as Man in all Places, the Cattle in Meadows and Stalls, the Wild Beasts in Woods and Deserts, Birds, Fishes, all sorts of Insects and creeping Creatures, such as Worms, Catterpillars, Flies, &c. in a word, every thing that has Life; for altho' some of them may make use of others for their Food, yet those that serve for Food to others, are themselves nourished by the Fruits of the Earth. Moreover, whereas this Earth does daily bring forth from its Bowels an infinite number of Herbs, Flowers, Plants, Shrubs, and Trees, for such various Purposes, and has done the same for so many thousand Years; can any one without Astonishment reflect, that since so much Earth has been made use of to the said Purposes for so many Ages, yet in so great a Series of Time it has never failed, nor entirely lost its Fœcundity? For that otherwise the Fruitfulness of the Earth is lessen'd by the continual Use of it, is well known to those who have seen the same come to pass in Land frequently sown more often than they are willing.

SECT. VIII. *An Experiment to shew, that Air makes the Earth fruitful.*

ASK now these Philosophers, so wise in their own Conceit, how they pretend to avoid these Mischiefs, which seem impossible to be obviated; and so to preserve themselves and all other Creatures from certain Death? And tho' some of these should acknowledge on any other account, yet, can he think that it happens without Wisdom and a determinate Purpose, that the Earth, which having lost his Fœcundity by too long an use, is rained upon from the Clouds, and by being only turned up several times, and exposed to the influence of the Air, recovers the said Fœcundity again? What is otherwise laying the Land fallow, than turning frequently the Parts of it upside down, and so affording an occasion to the Air to fructify the same? Now, whether this happens by the means of a Nitrous Salt, which is so much extolled by all the Gardeners, on account of its Fertilizing Powers, and which is produced in the Earth by the Air, we shall not here dispute: But the Matter of Fact has been experienced by me several Years ago, namely, that the barren Earth of a Garden that had been long sowed, lying fallow for a Year, and having been frequently broke into small Pieces, caused

caused the Seed, with which it was sown the following Year, to grow very thick and strong, without using Dung or any thing else to it, that we might be most certain of the Tryal.

SECT. IX. *Convictions from thence.*

NOW if a Man would but only consider these Methods of fertilizing the Ground, and afterwards earnestly weigh the following Particulars: *First*, That Air and Rain have the necessary Faculties of being subservient to this Purpose. *Secondly*, That this is frequently performed by both of them, without the Concurrence of any human Labour or Pains. *Thirdly*, That hereby the Earth in Woods and Deserts, remains in a Condition, tho' uncultivated, to supply the wild Beasts feeding therein with sufficient Fodder; I say, after having understood all this, can he accuse another of Stupidity, for humbly acknowledging the Goodness of the Great Preserver and Provider of all Creatures; because he will not suppose (without Reason, as he himself does) that all this comes to pass by Chance, and that no Wisdom has been here used, or need to have been, to impart to the Air, to the Rain, to the Earth, to the Beasts, all the requisite and particular Qualities, by a particular renewed Fertility of the one, to afford a constant Support to the other?

SECT. X. *It should seem as if the Earth would be render'd Loathsome, by Filth and Nastiness.*

IF all this be not sufficient to make a deplorable Atheist observe the Finger of GOD; let him tell us himself, whether he could have order'd the Structure of the Earth and of the things that are produced from it, with greater Wisdom than that which he now sees, at least he cannot deny but that,

I. ALL Plants, Men, and Beasts, proceed from the Earth: The first is plain in it self; and to prove it of the last, are not all living Creatures formed of the Fluids or Juices of those that procreate them, or at least expanded and rolled out to their respective Magnitudes? Do not these Juices proceed from their Food? the Food from Herbs and Plants? and these from the Earth? So that a continual Experience teaches us the same. Even Creatures that stand in need of Cloaths and Covering, receive it only from the Earth; the Wooll of Sheep, the Skins of Beasts, Flax, the Leaves and Barks of Trees, do all proceed from the Earth.

II. THAT nothing is everlasting; and that every thing living undergoes a kind of Death, and thereby is abandon'd to Stench and Corruption, is no less certain than the foregoing. So that every thing, when it has served the Purposes for which it was made, seems to be nothing more afterwards but an useless and loathsome Balast of the World, and fit to render the most agreeable Places (where Numbers of Men and Beasts do reside) deserted and uninhabitable by the Stench of so many dead Bodies and Carcasses.

III. THAT (to speak only of living Creatures) all the Meat with which they are fed, is converted in their Bowels to a loathsome Dung and Excrement, can be denied by no Body. Now if all that has ever been thus discharged by so many living Creatures as have been upon the Earth in so many Ages, should

should so remain in its disagreeable Form and Qualities, without any Change; must it not be confessed, that it would have been sufficient to render the whole Earth, and the Air surrounding it, exceeding nauseous and loathsome to the Inhabitants?

IV. ADD hereto, that so many Millions of Men and Beasts, that do only consist of the Productions of the Earth, have been so many Ages in the World; that it would not have been possible, without the intervening Care of a superior Wisdom, but that the fruitful Earth would have been very much diminished and consumed: So that altho' this Globe had no Destruction to apprehend otherwise, yet every thing that lived upon it would finally perish by the failure of the Earth's Fertility, and consequently of Food.

SECT. XI. *This Loathsomeness prevented, and Convictions from thence.*

ASK now an Atheist, whether he could sufficiently praise the Wisdom of such a one as had found out a Method to prevent all these nauseous and loathsome Inconveniencies? And if he himself could have done it, or could have taught Mankind the way whereby all corrupted Plants, all the Carcasses of Men and Beasts, in a Word, all other Putrified Bodies could be converted to a most profitable Matter, and to a most fruitful Earth, and even to such a one as should be capable of restoring Lands that were quite worn out and spent, to their former Fertility: I say if he himself could have found out such a Way, would he not think that he had laid a perpetual Obligation upon all Mankind?

Now this is what we daily see come to pass, and that without any Pains and Trouble on our Part.

SECT. XII. *The Circulation of almost all things from Earth to Earth; and Convictions from thence.*

CAN it be then thought that such ingeniously contrived Bodies of Men, of Beasts, and of Plants, proceeds all from the Earth, without the Concurrence of a great Director? and having appeared in such Forms, after a little while are turned to Earth again; which brings forth more, that are likewise to undergo the same Fate. And can an Atheist be so void of all Reason, as to conceive, that such a wonderful Circulation and Revolution of Things, during so many Ages, can come to pass without a wise Direction? Whereas, if he were required to perform the least thing analogous thereto by his Wisdom, he would be forced to confess, that his Understanding did not extend near so far.

SECT. XIII. *Several Texts of Scripture proving the same, and Convictions from the whole.*

THE Wisdom of the Almighty in his Holy Word has often plainly occur'd to me, in which this unconceivable Circulation of Things, from Earth to Earth again, is mention'd with great Energy. We shall not now speak of the first Production of all Things, according to which, Grass, Herbs and Trees, *Gen. i. 11, 12.* Living Creatures, *ver. 24, 25.* and

Gen. ii. 7. Man was formed from the Earth: Since this was done in a particular and unintelligible manner; but only observe from thence, that an Infidel has not so much reason to look upon any thing mention'd in this Chapter as impossible, forasmuch as we are taught by Experience, even now, that all these things come out of the Earth; and that what we daily see with our Eyes, does at most, only differ in the Manner from what is there related by *Moses*.

Now it is very credible that an Atheist, by whom the Manner how this was brought to pass has never been comprehended, would not make less Difficulty in admitting, that all these things proceeded from Earth, now at this time, if any one assured him of the Truth of it, than he does, that it was so in the beginning, upon the Words of *Moses*. From whence certainly appears with how little Ground these unhappy Men contradict Divine Revelation, only because that they don't understand it. And this their Blindness is so much the more to be pitied, forasmuch, as if they only attended to modern Experience, they would necessarily be of another Opinion, and acknowledge, that there daily happens before their Eyes something analogous to that which their Creator assured them of in the foregoing Text of *Genesis*, but which they would not believe upon his Word.

To illustrate the foregoing by other very plain Texts; Could *Solomon* speak otherwise than he does, about the Production of all things from Earth, and their Return to the same, in *Eccles. iij. 20*? *All go into one place; all are of Dust, and all return to Dust again.* And in *Chap. xij. 7.* in the following Words; *Then shall the Dust return to Earth, as it was:* where he calls Human Bodies (because they proceed from Earth, and after Death are turned into it again) even by the name of Dust. At the same time acknowledging, that that which the great *Jehovah* had said to the first Man, *Gen. iij. 19.* *Till thou return unto the Ground; for out of it wast thou taken; for Dust thou art, and unto Dust shalt thou return,* appeared even in his time, to a diligent Observer, to remain in the full force of Truth. So likewise the Composer of the civth Psalm, counting this among the Wonders of the most High, in *ver. 29.* where speaking of Men, Beasts and Fishes, he says, *Thou hidest thy Face, they are troubled; thou takest away their Breath, they dye, and return to their Dust. Thou sendest forth thy Spirit, they are created; and thou renewest the Face of the Earth.* Several other places might be here quoted from the Holy Scriptures, in which mention is made of Things being turned to Earth, which we shall now pass by; only adding this brief Remark, that the great Inspirer of this Word does not only point at the returning to Earth, but even to Dung also. Thus it is said in *Jeremiah xvj. 4.* and *xxv.* and *xxxij.* of slain Men; and on *Chap. viij. ver. 2.* even of their Bones too; *that they should be for Dung upon the Face of the Earth.* And again, in *Isaiah, Chap. li. ver. 12.* *Who art thou, that thou shouldest be afraid of a Man that shall die, and of the Son of Man, which shall be made as Grass.*

SECT. XIV. *An Experiment about Distilled Earth.*

NOW as wonderful as the Matter of Earth has been shewn to be, yet it has been but very slightly examined in the preceding Ages; and tho' in this last Age the Science of Nature has been more promoted than in several of the former, yet the Knowledge of the true Properties of the fruitful Earth does still remain very obscure. Now, that in so learned an Age the Enquiry into Nature should be wholly neglected, is not to be supposed; for which reason, perhaps, the Difficulty of saying any thing concerning it upon sure Grounds, may be the Cause that so little is written about it.

To say something of its common Origin: That the Earth can be produced from Water, has been shewn before, when we treated of the latter; and it appears from *Boyle's Experiment*, how Water by a continual Distillation, is turned into a certain Earth. But to say something particularly about Fruitful Earth; many Plants (as has been more largely shewn in the foregoing *Contemplation*, §. IV.) grow out of Water, which Plants, being corrupted or rotten, yield a fruitful Earth; in a word, this is confirmed by daily Experience, namely, that all Beasts and Plants may be converted into a Fruitful Earth.

We shall forbear to deduce any general Hypothesis from hence; since we have not yet made sufficient Discoveries upon which to found any certain Opinion; and we are not ashamed to own, with many others, that we do not fully know from whence and how Earth is produced: And that the Modern Experiments, tho' they show us many things, are not yet capable of imparting to us the right Knowledge of all that ought to be comprehended upon this Subject.

Now, since the Nature itself of the Fruitful Earth seems to have been but little enquired into as yet, I procured from an accurate Florist, one sort of such an Earth (for that there are several is plain from Experience): this Earth was composed of Cow and Horse-Dung, mingled with Sand, and had been cleared from Stones by sifting; I distilled it in a Glass Retort, and found that it yielded a Liquor, which being mingled with the Acid Spirit of Nitre, boiled up, or effervesced, to use a Chymical Word, the Quantity of this Spirit was in Proportion to that of the Earth; there likewise proceeded from it a dark stinking Oil.

Thus we also find, that rotten Plants and Herbs (among which this Dung must be reckon'd, since it proceeded from Grass, which is the Food of Cows and Horses) yields a *Sal Volatile*, and the like kind of Oil, as is well known to those that deal in Chymistry.

Now how this Property of the Earth can contribute to the Production of all Plants, and to the farther Fertility of the Earth, I shall not enquire here; since these Discoveries are more proper to carry us on to others, than to the concluding any thing that affords the requisite Certainty.

SECT. XV. *The Earth produces Instruments fit to be apply'd for the rendering it-
self more useful.*

AND that a Sceptical Mind may be more powerfully convinced of the Wisdom and Goodness of Him that formed the Earth : Let him consider with himself, how a Man that must live by the Earth, is born unfit and unable to Cultivate the same without any Instruments. Can he then see no Design of his Creator therein ? That this same Earth is not only disposed to produce Wood, but likewise Iron, of which Plows and other Tools proper for Tillage are composed. Now it was impossible without Fire to extract this Metal from the Matter with which it is mixed in the Mines, as it is well known to the Mineralists : So that tho' a Man were sufficiently provided with Earth, Wood and unwrought Iron, yet he would still want that which was necessary to render those things useful to him. But now again, continual Experience has taught all Men, that the same Earth does likewise furnish the necessary Materials of Fire, for making those things that are wanted ; and that Wood, Coals, Turf, and the like, are of its Production ; by which not only Iron is separated and purified from the foreign Matters that cleave to it, and is converted into the Instruments for Plowing and other Uses ; but moreover, that the raw Fruits, which are likewise produced by the Earth, are ripen'd and digested by the Fire, and so render'd fit for Food.

SECT. XVI. *Of Alchymists, and an Explanation of the Texts in Exod. xxxii. 20.
and Deut. ix. 21. about Gold.*

NOW since we have here made mention of Iron, so far as it relates to cultivating the Earth, there would have been a large Field to treat more minutely concerning the same, and other Metals and Minerals, such as Lead, Tin, Copper, Silver, Gold, and Precious Stones, which are all the Fruits and Productions of the Earth : But I shall only make these two Remarks *en passant* about Gold : *First*, How many Alchymists (to be pitied for their Folly, if not despised for their mistaken Avarice) were found in the last Century, who left nothing unattempted to make Gold from other and cheaper Matter. Innumerable Things were tried by innumerable Methods, to compass this End ; not only by great and eminent Persons, but by those of a middling and smallet Understanding ; but all in vain hitherto : And the only Fruit that is to be reaped thereby, has been, that from hence a strong Proof may be fetched to convince those conceited Philosophers, who imagine they understand every thing, of the defect of their Judgments ; and that something has place in Nature, concerning the Production of things, which far surpasses their Wisdom. *Secondly*, What I find myself obliged to insert here, is an Answer to the Objections which many Unbelievers have brought against the Authority of the Books of *Moses*. We read in *Exodus xxxii. 20. that Moses took the Calf which they (the Israelites) had made, and burnt it in the Fire, and ground it to Powder.* The same Story is expressed in *Deut. ix. 21. in these Words ; I took your Sin, the Calf which you had made, and burnt it with Fire, and stamped it, and ground it very small, even until it was as small as Dust.* And here our Adversaries think

they have discover'd a great Argument against the Divinity of this Holy Word; forasmuch as all the Experiments that have been made upon Gold, even by keeping it whole Months in our strong Fires, have always hitherto taught us, that it can only be Melted, and not Burnt in such manner as to be beaten to Dust: Wherefore, according to them, this burning, and afterwards grinding to Dust, seems to be entirely contrary to the Nature of Gold. Now not to return for Answer what has been already said by many very learned Expositors, in order to remove this Difficulty, and whom they, who are curious, may consult; I shall only add,

First, That altho' Gold in itself, and alone, is uncombustible, and seems incapable of being reduced by our Fire to such a Condition as to be stamp'd to Dust; yet it may be done by the Addition of some other Matter, as Chymists know very well; and so do they particularly, that make colour'd Glass and Counterfeit Jewels, which, by mixing Gold with them, acquire the Colour of Rubies, and which, together with the said mixed Gold, can be beaten to Powder. Now it is not said in that Text that *Moses* used no additional Matter to bring the Gold to such a State; so that for this reason their Argument will not pass.

Secondly, This Argument is not conclusive, *No body knows how Gold can be burnt, therefore Gold cannot be burnt*; For if this be good Logick, they must proceed and say farther, *No body knows how Gold can be produced, therefore Gold cannot be produced*; which Experience teaches us to be false.

But, *Thirdly*, to convince these miserable Seekers of Objections beyond a Reply, that it is by no means inconsistent with the Nature of Gold to be thus burnt by Fire, as also that it can be beaten to Dust without any Mixture or Addition, we need only refer them to the Experiments performed by great Burning-Glasses, some few Years ago.

SECT. XVII. *Gold may be burnt and reduced to Dust.*

THUS, in the *History of the Royal French Academy*, 1699. p. 113. we find this Observation mention'd among those of Mr. *Tschirnhaus*, the Inventor of the said Burning-Glasses; That all Metals being placed in the Focus of the Burning-Glass, will run into Glass; and that Gold in its Vitrification, assumes a fine Purple Colour.

But very nice and accurate are the Observations which Mr. *Hornbergh* made upon Gold in the pure Fire of the Sun, in the Year 1702. p. 186. and 1707. p. 50. as it is largely related in the Memoirs of the said Academy; where, after having acknowledged that Gold is not diminished in our common Fires, it is shewn, that by such a Collection of the Rays of the Sun in a Focus, or very near it, Gold is evaporated and turned partly into Fumes, and partly into Glass; which, as the Author himself expresses it, p. 189, 190. *is a real Conversion of this heavy Metal into a lighter Glass*. At the end of the Memoir we find these Expressions; and thus we see by these Observations, that the Idea we had formed to ourselves in Chymistry, of the Fixity or Fastness of Gold, cannot obtain any longer

Now

Now I ask those who have hitherto made this Text of Scripture a Foundation of their Infidelity, whether they must not confess, that their Arguments are quite defeated, after the making of this Experiment; and that Gold is really burnt when it is partly evaporated, and partly changed into Glass? At least, it is a Chymical Truth, that Evaporation and Vitrification is the only thing that can be understood by *Burning*, if we take that Word in its utmost Force. Besides, that hereby Gold, which does not otherwise easily appear capable of being made small by any Beating or Grinding (tho' in the last Age a famous Chymist has shewn us, that it may be done by a Mill made on purpose) is brought into such a Condition, that after its Vitrification it may be ground to Dust. So that we here see all the Circumstances required by the Text, come to pass in the Business of Gold.

I do not say that that Man of GOD, *Moses*, did in this Case make use of such a Burning Glass, since the first mention of those Instruments is made by *Aristophanes* (see the History of the Royal Academy of Sciences, 1708;) but they were very imperfect, and like round Balls. It would have been sufficient, if he had the Knowledge of any such Fires as were so Pure and Strong as these Rays of the Sun thus collected. But that which is properly before us here, is, that from this Experiment it is plainly and undeniably shewn, that what has been said about the Burning of Gold, is possible: And, as has been shewn above, *Moses* might have made use of the same or other kind of Mixtures, which the said Text does not exclude.

SECT. XVIII. *About Precious Stones.*

FROM Metals it seems as if we ought to pass to the Consideration of Precious Stones; which if they be not beholden to the Earth for their Origin, at least almost all of 'em are found in and about the same. Those who acknowledge the Greatness of an All-creating GOD, may in this last Instance remark how gracious and bountiful he has been to Mankind, by taking care even for Ornaments likewise, and by producing out of the Earth, Creatures of so noble a Lustre for that Purpose; by rendring them so far wonderful, that some, and the chief of 'em, do excell in Firmness and Incorruptibility, everything that is yet known; whilst in the mean time their particular Structure has remained a Secret to us for so many Ages.

One of the Properties of Diamonds, till then unknown, has been discover'd by Mr. Boyle, and since taken notice of in the *French Academy*, 1707. p. 1. namely, that a polish'd Diamond being rubb'd against a Glass, will, in a dark Place, produce a Light as clear as that of a Burning Coal when strongly blown.

SECT. XIX. *Atheistical Objections answer'd.*

I FIND myself obliged to say something of the other Stones, tho' less valuable; not that I am able to demonstrate the wonderful Ends of the Creator in them, but only to obviate an Argument which the Atheists raise against the Use of so many Rocks and other kinds of Stones, which seem to them entirely unnecessary.

They think they have here met with something which does as it were favour their unhappy Notions ; to wit, that if there be a God who has made all things with Wisdom and Goodness, to what purpose then has he made so many useless Flints, so many Rocks and Stones, that seem to be good for nothing ?

But will these miserable Philosophers, some of whom are otherwise Men of good Sense, pretend to offer such an Argument, that because the Use of those Stones is hitherto unknown to them, therefore they have none, nor yield any Service to the Creation ?

To be convinc'd of the Vanity of such an Argument, let them only go into the Shop of any Artificer, and view the numerous Tools he uses in his Trade, most of which seem to be useless, because they don't understand the Design and End of the Workman ; but when they behold the Works produced thereby, they cannot forbear wondering at the Skill by which the said Tools are adapted to the Service they perform. Now if they observe some things upon this great Theatre of the Earth, the Use of which is unknown to them, can they indolently go on in denying the Wisdom of him who made them, and still maintain that there is no Service in them ? Especially, since following Discoveries have frequently shown, that things which were thought to be of no kind of use, have eminently contributed to render Mankind very happy. It was but a little while ago, that such a Philosopher advanced, that Hills and Mountains were not only useless, but prejudicial to our Globe ; whereas, if he had receiv'd the Observations and juster Conclusions of wiser Men, he must have been convinc'd, that in many places the Earth would not have been habitable at all but by the help of Mountains, because without them the Country would have been burnt up with Heat, and all the living Creatures suffocated with Thirst. And let such a Man tell us, whether there be not more Wisdom shown in making a hard Stony Bed for a rapid River, and Rocks to baffle the Rage of the Sea, and to supply Islands for the Advantage of Navigators, than in the most fruitful Gardens or Meadows ?

SECT. XX. *Concerning the Loadstone.*

HE who had never seen a Loadstone before, would according to the *Philosophy of Ignorance* (for thus we ought to stile the Philosophy of those Men, who, because they cannot discover the Use of any thing, do therefore presently conclude that it is useless) think that this Stone is one of the most useless things that GOD has created ; to say nothing of the contemptible Appearance of it.

But in case he were afterwards informed, that this Stone had not only the Property of attracting Iron it self, and of rendring that Iron capable to draw other Iron to it ; (and this it does in such a manner, as even in the present Age, after so many Observations, with which whole Books are filled, is confessed to be still unknown by all true and unbiassed Philosophers :) Could he then forbear to look upon this despicable Stone, as wonderful ?

But in case one should disclose to him afterwards those Properties thereof, by which it makes a Needle point to the Northern Parts of the World, and by that Means chalks out a Path in the midst of the Sea for Ships, inasmuch, that without it none durst venture to launch out into the great Ocean, and all Communication between those Parts of the World, that are so remote from one another, would be entirely interrupted: Would he not then, when he saw the Merchandize and Product of other Countries, which are attainable by the help of this Stone, pronounce it to be one of the most useful things in the World, and own himself, with the utmost Gratitude, obliged to receive it as a most valuable Present from a generous Benefactor?

SECT. XXI. *When the Virtue of the Loadstone was discover'd.*

BUT lastly, when he adds to all this, that the Power of attracting Iron was long enough ago known to the Ancients, whereas that of finding out the North, and of serving for a Compass to Mariners was concealed from them; and that upon this occasion not only Christians in general, but among them, likewise great Mathematicians have observ'd that which is noted by *Descartes*, in the Preface of his Mathematical World, namely, that about 300 Years ago, it pleased the great GOD to reveal this use of the Loadstone, when he had decreed, according to his Divine Providence with respect to Mankind, to reveal his Service and his Son to those Nations that were separated from us by the whole space of the Ocean. Will he judge that the Sentiments of those Persons are so groundless, who acknowledge in this Stone, and the Use thereof, the Wisdom of GOD, and his wonderful Direction and Rule over all things, at the time of the Discovery of the Properties thereof.

SECT. XXII. *The Roundness of the Earth.*

IF we now pass on from the Matter of the Earth to the Structure of the Globe itself, as it consists of inhabitable Land and Water; could any Body that surveys with his Eyes the appearing Plane and Flatness thereof, have ever admitted it into his Thoughts, that the same is Round? And not much rather, by what he might conclude from the Motion of heavy Bodies downwards, affirm, with many of the most Learned of the Ancients, that it is impossible to ascribe a Globular Figure thereto? Forasmuch as those things that are under us, if they exerted their Gravity after the same manner, and according to the same way, would seem to have no Support, but must fall into the Air, which is below them. Whereas, nevertheless, modern Experience teaches us, that the greatest Wisdom cou'd have contriv'd no Figure than that of a Spherical or exactly Round, in order to make of so small a place, so great and noble a Theatre of numberless Wonders. And can any one then satisfy himself with the bare Assertion, that this Globe of the Earth has acquired such a Figure by Chance, or at least without any Understanding?

What various Opinions have there been concerning its Shape in former Ages? With respect to Astronomical Observations, by the Roundness of its Shadow upon the eclipsed Moon, and by the Remarks, that upon the

Sea, the Masts of the Ship are seen before the Ships themselves; and that the Ships may be seen by standing upon an Eminency, beyond the interposing Convexity of the Earth, which could not otherwise be seen. This render'd the Globular Figure of the Earth very probable, till the same was afterwards farther proved and confirmed experimentally, by several Voyages round the whole Earth.

If People in those dark Times had not so much relied upon their Understanding and Argumentations as many do at present, and if they would have given Credit to what the Great Creator of the Earth has said himself concerning it, they would have long since been satisfied of the true Form of the Earth: See *Isaiah* xl. 22. *It is he that sitteth upon the Circle of the Earth.* Can any thing more plainly express the Globular Figure of the Earth?

SECT. XXIII. *The Earth is a flattish Bowl.*

SINCE we are now speaking of the Figure of the Earth, I cannot well pass by that Text of *Jeremiah* vi. 22. *Thus saith the Lord, behold, a People cometh from the North Country, and a great Nation shall be raised out of the side of the Earth:* Which words do likewise occur in the said Prophet, *Ch. xxxi. 8.* and *Ch. l. 41.* according to which the North is stiled the *Sides of the Earth.*

Now by the Sides of any thing, for Instance of a Plank, of a Beam, of a Ship, of a Man, or Beast, &c. we are wont to understand those Parts of the Circumference thereof, between which the Bodies themselves are Smallest or Thinnest, or otherwise between which the shortest Diameter thereof lyes.

Wherefore, if we suppose that the Earth is not perfectly globular, but that the Axis of it, or a Line drawn from the Northern to the Southern Pole, is shorter than a Diameter at the Equator; and that all the Diameters of the Earth are longer as you approach the Equator, and shorter as you go towards the Poles, the North and South Parts may be deemed both the *Sides of the Earth.*

Now 'tis well enough known to those that have look'd into the latest Observations of the accurate Moderns, that tho' they are wont to term the Earth a Spherical Body, without having any regard to the Inequalities that may be occasion'd therein by Mountains and Vales, yet it is not perfectly globular, but has a greater Protuberancy under the Equator, and grows continually lower or flatter towards the Poles.

Upon the Observation, that the Pendulum of a Clock at *Caienne*, near the Equator, must be $1\frac{1}{4}$ of a Line, or of $\frac{1}{12}$ of an Inch shorter, to strike exactly a Second, than it was necessary to be at *Paris*. Mr. *Huygens*, in his *Treatise of Gravity*, asserts that the Earth is flatter at the Poles.

In Sir *Isaac Newton's Princip. Philos. Prop. XIX. Lib. 3.* we see the same; as likewise in Dr. *Gregory's Astron. p. 36. and 268.* and in Mr. *Whiston's Praefat. Phis. Mathem. Prop. XCIII. Corol. 2.* we find these Words, besides what is said in other Places thereof; *Since it is known by Observations and Experiments, that our Globe is actually higher at the Equator than at the Poles.* In the History of the French Academy, 1700, p. 144. and in the Memoirs, p. 227.

we find Observations taken at *Lisbon* and *Paraiba* in *America*, which seem expressly to confirm the shortening of the Pendulum in the Approach to the Equator, and consequently to prove the greater Flatness of the Earth at the Poles, tho' the exact Greatness is scarce to be determined by these Observations.

But that we may not be liable to the Difficulties and Objections that shall be made against the Hypotheses used by some for the Proof thereof, it is very remarkable, what is said upon the same Subject, in the History of the said Academy for the Year 1701. p. 120. and in the Memoirs, p. 237. &c. where Mr. *Cassini*, carrying on the Meridian of *France* to the *Pyrenean* Mountains, by order of the King, has nicely measured the Length of each Degree of the same, and found in $7\frac{1}{3}$ Degrees between the Parallels of *Amiens* and *Coljure*, which he has compared with each other, that the Quantity of each continually increased as they drew nearer to the Equinoctial, and consequently decreas'd as they approached to the Poles. So that, without contesting too strictly the exact and Geometrical Figure of the Earth, and without admitting any Hypothesis for a Foundation, in case what Mr. *Cassini* has really found in each of these Degrees, obtains in all of 'em from the Equator to the Poles, certainly the Equator or Equinoctial itself is greater than any Meridian or Circle passing thro' both the Poles: And the Earth is really a Globe, but a little flattish at the Poles. The same may be observed by the help of Telescopes in the Planet of *Jupiter* itself, and was so done by Messieurs *Cassini* and *Flamstead*; See *Whiston's Prop.* 93. and others.

Now, whether this be the Experiment of which Mr. *Whiston* makes mention in the place above-quoted, I know not, because I do not find them added to it. This is certain, that this Author, in his *Prælect. Astron.* II. *Prop.* II. p. 8. of the Earth, says, that it is *nearly, or almost Spherical*; yet with so little Difference, that he reckons them among those Trifles that are not worthy to be taken notice of in Astronomy, because the Difference which the small Flatness thereof may occasion, is in a manner insensible.

SECT. XXIV. *The Gravity of all Earthly Bodies.*

I HAVE oftentimes consider'd with great Astonishment, that wonderful Motion which the Philosophers call *Gravity*, or *Heaviness*, and by which every thing that we know upon the Earth is attracted or driven down and towards this Globe.

I shall not here relate nor dispute the various Arguments of Philosophers about the same; whether it is to be consider'd as accidental only, and whether it be occasion'd by the Highness of other Bodies, which force the heavier downwards. This is however true, that all Corporeal Things that are known to Mankind upon this Globe, have their Gravity or Weight, nor excepting the Air and the Fire, nor even that fine and pure Fire itself which has first passed thro' Glafs: All which, according to the Discoveries of these Times, have been visibly proved by a nice Balance to have their Weight. See *Boyle de penetrabilitate vitri à ponderabilibus partibus flammæ.*

Yea,

Yea, that the pure Light itself, being collected by a Burning-Glass, may be united to other Bodies, and render them more heavy, will be shewn hereafter in *Contemplation XXIV.* by the Experiments of Monsieur *Homborgh.*

Now how strongly this Gravity operates, does even appear from the Pressure of Bodies, which do otherwise seem to be without Motion. From hence it is we see great Ships sink, and oftentimes very strong Floors of Houses fall in by being over-laden.

Now I ask any reasonable Person, whether he can believe, that stupid and insensible Things, which cannot produce the least Motion in Themselves, are capable of observing such exact Laws without the Direction not only of a Powerful, but likewise of a Wise Being? For in Case C be the Centre of the Earth (*Tab. XV. Fig. 3.*) and the Circle drawn from thence be a great Circle upon its Superficies, and the Lines FG, HI, KL, MN, that touch the said Circle, represent the Horizons of each Place; every one knows, that if a Stone, or other heavy Body, were let fall at A, it would move according to the Line AC; if at B, according to BC; at D, according to DC; and at E, according to EC: and that this is a true Position, is well known to those Pilots that have sailed partly or wholly round the Earth, who must all bear Witness, that such is the Method of their Fathoming in the different Places in which they happen'd to be.

Now let the Cause of this Gravity be such, as every one, according to his own Philosophical System, shall think fit; yet he must nevertheless acknowledge, that without this Property the Earth would be uninhabitable, especially if he comprehends what has been said above concerning the Weight of the Air and Water.

SECT. XXV, and XXVI. *The Centre of the Earth is a Nothing.*

NOW, not to ask whether any one can imagine that it comes to pass without a wise Direction, that a Body wholly ignorant and insensible, being placed at A, shall move from A to C; and being at E, from E to C, along a straight Line directly opposite to it; and that in all Places where any Body falls down upon the Earth, it shall always chuse the nearest and shortest Way to the Centre thereof: Those who seriously contemplate this great Wonder, that all Bodies, how large and unweildly soever they be, without the least knowledge of what they themselves are doing, will move with so dreadful a Force towards a Mathematical Point, to a mere *Ens Rationis*, which has no Existence out of the Thoughts of him that conceives it; and (tho' it may be justly called in Bodies, a perfect Nothing) will yet remain hanging to it: Can they, without acknowledging the Wisdom of GOD in his Holy Word, read the Expression made use of by *Job*, ch. xxvi. v. 7. *He hangeth the Earth upon Nothing?*

As great a Paradox as this may appear to be, the obdurate Atheist, if he understands any thing of the Mathematicks, must own, that it is an undeniable Truth, as the Holy Penman has there expressed it. Is not every thing heavy among all Earthly Bodies that have yet fallen under Humane

Enqui-

Enquiries? Does not this Heaviness cause every thing to descend towards the Center of the Earth? Does not the whole Body of the Earth dispose itself into a Circular Figure about the said Center? And therefore in the very Words of *Job*, does not the Earth by such Gravity hang upon nothing on all Sides? Is not then the Centre a perfect *Nothing* in itself, and exists only in the Idea of Men? Why do we hear *Euclid. Defn. I. Lib. 1.* describe the same thus; *A Point is that which has no Part?* And to shew that the following Mathematicians held it to be no Part of Matter, see what *Clavius* says of it in his Annotations, namely, that *no Example can be given of it in material things.* Thus we see that *Whiston*, in his Treatise abovemention'd, *Prop. LXXXVIII. Corol. 2.* says, that the common Centre of Gravity of things in this World, being only a Mathematical Point, is plainly a *Nothing*. The like Testimonies one might produce from more Mathematicians. Now if it be not material, what is it then other than a *Nothing* in material Things, and a mere Notion only, that we form to our selves of the Bounds or Limits of something? The Reasons produced by true Mathematicians, to shew that a Point is without Parts and Magnitude, may be found by those that are unexperienced in these Studies, (and who are therefore shock'd at this Assertion,) elsewhere, this not being the proper place for it, it being sufficient for our purpose to have prov'd the Truth of *Job's* Words, and so far to have consider'd the Nature of *Gravity*, as to shew, that it is impossible for any one to ascribe it to Chance, or to ignorant Laws of Nature; because if any Man can imagine that a Body being successively put into numberless places all round the Earth, can always move itself by numberless different ways to its only Centre by meer Chance, or without the Direction of a wise Being, he must be deplorably blind. It ought therefore to be imputed to the Will and Power of GOD only, especially since no Man hitherto has been able to assign any other satisfactory Cause: Insomuch, that after all the Disputes and Cavillings about it, the greatest modern Mathematicians and Enquirers into Nature have been forced to come to this Conclusion, That Gravity is a general Law, and as old as the World itself; and that GOD was pleased to stamp it upon Matter in the Beginning; and, that therefore we ought no more to ask how it comes to pass that all Bodies gravitate, than how it happens, that they are moved. It is well known, that this is the Language of some of the greatest Mathematicians of this Age.

SECT. XXVII. *The Globe of the Earth keeps the same Obliquity of its Axis.*

HAVING made some mention of the Gravity, I cannot forbear observing, with great Reverence, that surprizing Wonder which Natural Philosophers (whatever some of 'em may pretend to conjecture) have acknowledged to be one of the Secrets of the Great Creator; and even to this Day are forced to consider it as such. Now, whether we suppose that the Globe of the Earth, *p e m f*, (*Tab. XV. Fig. 4.*) stands still, and that the Starry Firmament *P E M F*, together with the Sun *O*, and the rest of the Constellations, daily move about it; or whether, with others, we suppose, for greater Conveniency in some Occasions, that in *Tab. XV. Fig. 5.*

the said Globe of the Earth is carried round the Sun O, thro' A, B, C, D, and is daily moved about its own Axis pm ; this is certain, that the said Axis pm does always respect the same Place P and M of the Heavens, in the fourth Figure, or remains always parallel to itself in the fifth Figure; and that so the Earth, without any support, does thereby always preserve its own Parallelism and Obliquity of the Axis, at least so much, that the Astronomers have never been able to observe it otherwise; and such as have imagined that they have found it otherwise, have never been able to prove such a Discovery. And, which is still more wonderful, notwithstanding the Globular Figure of the said Earth, and notwithstanding the Opinion that many have entertained, that the Earth's remaining in its present State and Obliquity, is owing to the Equilibrium of its Parts, the same has so frequently undergone such great Revolutions, that it should seem almost impossible to those that judge rightly of things, that it has not thereby been confounded and dissolved, or at least put into different Motions.

SECT. XXVIII. *Without the Obliquity of the Axis of the Earth, there would be reason to apprehend a General Destruction.*

FOR a Proof hereof, let any one consider those dreadful Burning Mountains, which are found in so many Parts of the World, and at such Distances from each other, by which the Earth has been destroyed in so many Places: Especially if those Fire-pits (as one may perhaps conclude from the Relations of them given us by Mr. *Baglivi*, p. 510, &c.) according to the Sentiments of many of the Learned, do entertain a Communication with each other, by great Rivers of Fire extending themselves from one Part of the Earth to the other, and even under the Bottom of the Sea too: For which reason the Earth seems necessarily to become lighter in those Parts where so much of it has been burnt, and vomited out in Smoak and Ashes.

Add to this those terrible Inundations, among which, according to all Traditions, the whole *Zuider-Sea* is one, and the violent Streams of such great Parts of the Ocean, which by Winds, by Ebbings, and Flowings, and other Causes, do remove such an unconceivable Weight of Water from one Part of the Globe to another; by all which the Gravity thereof must needs be changed into several Places: Not to mention those Earthquakes that are felt over all the World, by which this Globe being moved, may make us all justly apprehend a Change in the State and Condition thereof.

Now in case that by all these Causes acting with such terrible Force, it should once happen that the Earth should totter, and depart from its Place in any manner, what could there else be expected but general Ruin and Destruction, where every thing changed its Air and Climate. For let it be supposed, that those who in *Tab. XV. Fig. 4, 5.* dwelt under the Line ef , or in the Torrid Zone, near to it, should be carried by such a Shock of the Earth to some of the Countries under the Poles p or m , or one of the Frigid Zones; by which means those Nations which now dwell under either of the Poles, would be carried into the stifling Air under or near the Equinox. Can it then be doubted, that all Creatures that were accustomed to the

the violent Heat of the one, even Men, Beasts and Plants, would for the most part perish and be destroyed, by being transplanted to the excessive cold Regions, and so on the contrary. Now all these Evils, which would certainly follow, are hereby obviated; and altho' the Globe of the Earth might undergo so many Revolutions in its Parts, tho' it should become heavier in one Place, and lighter in another; whereby the Balance of its Structure might be alter'd, yet it would however stedfastly and immoveably preserve the same Obliquity of its Axis.

SECT. XXIX. *Convictions from thence.*

Now that among so many Causes, which seem adapted to produce a contrary Effect, the Globe has unchangeably kept this its State and Condition, can result from nothing else than the miraculous Operation of a mighty Providence. For if any one should ascribe it to a Law of Nature, to its own Gravity, or, as some think, to a magnetical Virtue, let him tell us how it comes to pass, that such a Law of Nature is always unvariable in its Effects, when at the same time the Earth, upon which these Laws operate, changes its Composition with respect to Levity and Gravity, to Cavity and Solidity.

SECT. XXX. *The Earth remains above the Water, notwithstanding its greater Gravity*

Now in order to lay before an Atheist something that he shall not be able to fathom or conceive; Let me ask him the reason why, since Earth is heavier than Water, the Waters do not stand above the Earth, surrounding the same in the like manner as the Air, since it seems to be past doubt, that one should follow as well as t'other, from the Laws of Gravity?

'Tis in vain for any one to alledge, especially such a one who will not acknowledge herein a Wonder-working GOD, that the Sea and Waters being shut up in the Cavities of the Earth, it would be impossible that such a thing could happen. For supposing (as the Experience of Inland Waters, for Instance those of the *Harlemer Meer*, or *Lake of Harlem*, has taught many People to their Damage) that the continual Beating of the Waves would in time wear away every thing; it seems to be a necessary Consequence, that the Banks and Shores being thereby washed away, this Matter would first mingle itself with the Water, and afterwards sink to the Bottom by its greater Weight, and so render the Seas, and other Waters, more and more shallow; by which means the dry Land continually decreasing, the whole Earth would at last be encompass'd and cover'd with Water, tho' not so deep as the present Cavities of the Sea. Yet we see the contrary happen, and the dry Land remaining inhabitable, notwithstanding the Rage of Seas and Rivers.

SECT. XXXI. *Concerning the Torrid Zone.*

To pass on to something else: It is well known that all the Geographers do divide the Superficies of this Globe into five Zones. The first they

call the *Torrid Zone*; this is that part of the Superficies which extends itself from the *Equator e f*, (*Tab. XVI. Fig. 1.*) on each Side, to the *Tropics c d*.

Now that the old Geographers held it for an unquestionable Truth, that this Zone was barren and uninhabitable by the intolerable Heat, appears strongly enough from their Writings; nor were they so much to blame, if we reflect upon the Influence of the Sun in other Parts of the World: Since this great and burning Luminary moving twice a Year in the Circle *A Y D*, called the *Ecliptic*, or the Sun's Way, passes directly over those Lands that lie between the two *Tropics a b x c d*.

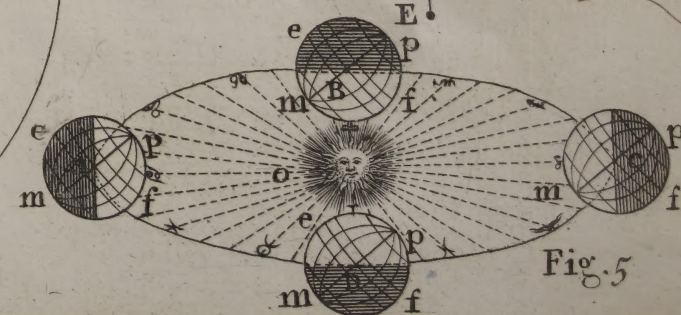
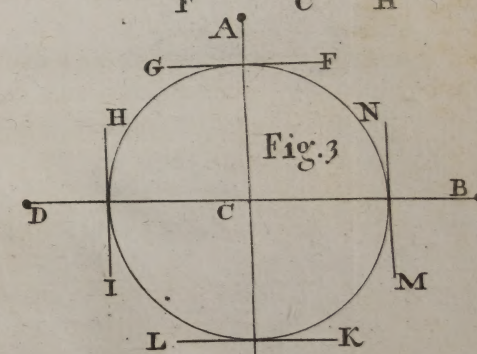
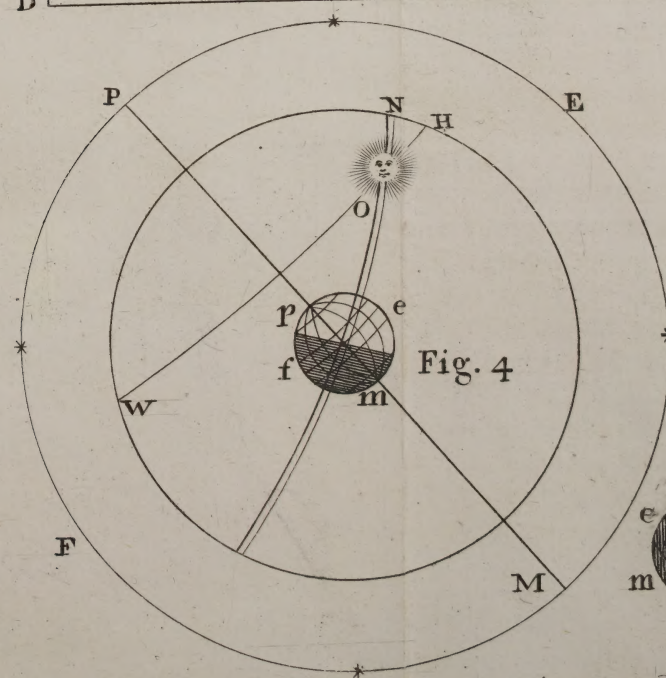
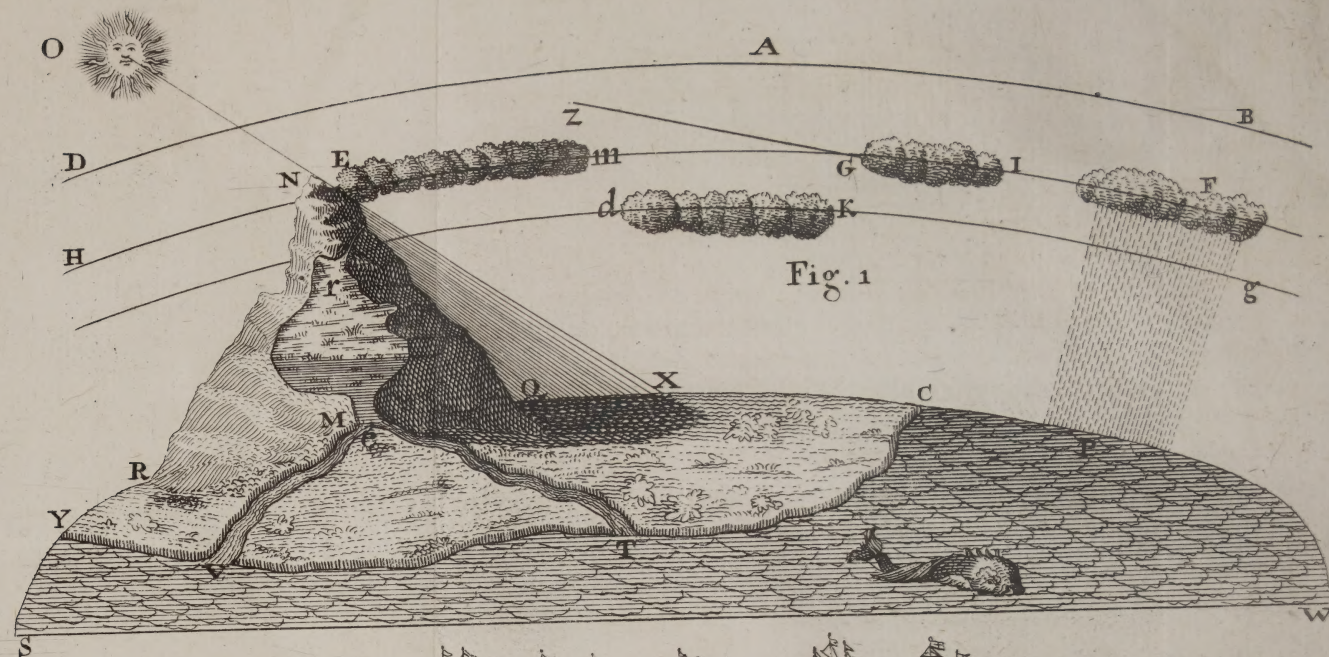
And this very rational Notion, as to outward appearance, had so long obtained every where, till Experience teaching the contrary, has therein manifested the Divinity and unconceivable Wisdom of the Great Creator, who has graciously prevented, by other Means, this all-consuming Heat, which, with respect to the Situation of those Countries, and the Course of the Sun, seems to be a necessary Consequence, from destroying the same.

SECT. XXXII. *The Torrid Zone inhabitable by means of Mountains.*

To be assur'd of this Wonder, we need only take the aforementioned Island of *St. Thomas* for an Example: This Island lies under the Line, as here at *X*, in the middle of the *Torrid Zone*; of which nevertheless, all that write about it, do unanimously witness the Wholsomeness of the Air for the Inhabitants, and the Fruitfulness of the Country. To which purpose we need only consult the little *Atlas of Mercator*, or any other Books that have treated of the same.

Now I beseech every one that can yet doubt whether the World be made with Wisdom, to reflect with himself, whether it may be deduced from the ignorant Laws of Nature, or from mere Chance, that, to the end the Sun should not render this Island uninhabitable, there is a great Mountain placed in the middle, and overgrown with numbers of Woods; the Tops of which, notwithstanding that the Heat may seem to dry them quite up, are always cover'd with so many Clouds, that the descending Waters which proceed from thence, are not only sufficient to produce other Fruits, but even Sugar-Canes themselves; insomuch, that in the very hottest Days, this Mountain appears cover'd with a continual Cloud: the Reason of which is, that a much greater Quantity of Vapours are then attracted by the Sun from the Sea; and the Air being likewise much more rarified by the Heat, carries the Vapours of Water that are mixed with it, more to the cold and shadowy Places of this Mountain, whereby they are press'd more closely together, and so the Weight of the Clouds is increased. Now how the Mountains concur in producing these Effects, has already been in some measure shewn before.

Now if any one should refuse to acknowledge a gracious Providence of God in this whole Matter, and wou'd pretend, that this is only peculiar to this single Place, and consequently, that it may be the Effect of Chance, he may learn from the Description of *Madagascar*, in the Geography of
Mr. Robbe,



Mr. *Robbe*, and others, that there are likewise Woods and Mountains in the middle of that Island, from whence Rivers flow on all sides, which render that Country (tho' lying in the hottest Part of the World) in respect to the Sun, equal in Fertility to the best Climates of the Earth: And this you will find observed in several other Places.

SECT. XXXIII. *The Inundation of Rivers do likewise render the Torrid Zone habitable.*

BUT in case any other of these miserable Philosophers should again, according to their manner, start new Difficulties, and fancy, that since what has been advanced above, has happen'd in several Places, it might be the necessary Consequences of Natural Laws, they may likewise be convinced of the Unreasonableness of such Opinions, from other and different Means, which, besides the foregoing, the Wisdom of GOD has been pleased to make use of in rendering those Countries fruitful, which would be otherwise quite scorch'd up by the Rays of the Sun.

Now, not to speak of *Egypt* again, one part of which lies under the Tropic *a b*, and where it is thought to be the very hottest, because the Sun does not only pass twice a Year directly over their Heads, as it happens in all Parts of the Torrid Zone; but also, because it remains a much longer time over the Countries lying about the Tropic than it does at the Equator, which it passes by more swiftly; and yet this *Egypt* is made one of the most Plentiful and Fruitful Countries of the World, by the Overflowing of the River *Nile*. I say, besides *Egypt*, the dry and barren Country of the *Blacks*, commonly called *Nigritia*, or *Nigritiarum Regio*, may serve for a Proof; which likewise stretches itself from the 8th to the 23d Degree of Latitude, and consequently very near to the Tropic of *Cancer*, in the hottest Part of the Torrid Zone, and is overflowed in the like manner by the River *Niger*; which leaving a kind of Mud every Year upon this scorched Country, makes it become the most fertile of all *Africa*. See concerning the same, Mr. *Robbe's* Geography, as also that of *Varenus*, *Lib. I. Cap. XVI. §. 20.* about several Rivers besides the abovemention'd, that produce the same Advantages. Many of which there named, and amongst them particularly the River *Zaire*, do overflow their Banks yearly; so that this last renders the Kingdom of *Congo*, where the Air in clear Weather is intolerably Hot, exceeding Fruitful in all sorts of Herbs and Plants that are good for Food. He therefore that is surprized hereat, and has a mind to be farther informed, how in such a burning Climate the Earth yields so great a Plenty of all things, may learn from the abovemention'd Geography of Mr. *Robbe*, and the so often praised *Varenus*, how the Rivers *Indus* and *Ganges* overflowing always in *June*, *July* and *August*, do Water whole Kingdoms lying about 'em, and make them Fruitful to a great Degree; as they likewise serve for a sufficient Provision of Water to the Inhabitants during the rest of the Months, in which there hardly falls any Rain.

After how wonderful a manner the Heat of this Torrid Zone is farther qualified in several Places by cool Breezes and Rains, is likewise shewn by

Varenus;

Varenius, Lib. II. Cap. XXVI. §. 11. even so far, that by other means, which the Wisdom of the Almighty has been there pleased to use, the Seasons seem frequently to run contrary to the approaching and receding of the Sun. It would be too tedious, and, according to all probability, an unnecessary Work too, to enquire into all the Causes thereof.

SECT. XXXIV. *Convictions from hence.*

Now let me once again ask these Philosophers, that are really worthy of Compassion, and who will have all things come to pass as they are, without the Wisdom of the Creator and Preserver of all things, whether, if any Body had found a Method to furnish a little District of Land with a milder Air, and with as much Water as is wanted, and which without the same must have perished by Drought and Barrenness, together with all the Men, Beasts and Plants that were upon it; whether it could be denied, that the Wisdom of Him that found out and effected the same (especially if the Knowledge and Power of the greatest Number and most Skilful of Men would not have sufficed for that Purpose) were not worthy of the highest Praise; and whether they, or any one else, could imagine, that the Canals and Aqueducts whereby in the drained Meers or Lakes of *North-Holland* the Lands are water'd in dry Seasons, and the Cattle are provided with Drink, could have been brought about without the Contrivance of a Skilful Engineer?

Now this is what we see performed, not in drained Meers or Fens, but in vast Kingdoms; not a few Cattle water'd, but Millions of Men, Millions of Wild and Tame Beasts, Millions of Trees, Shrubs, Plants, Corn, and other Herbs preserved alive thereby; not some few Acres of Land, but Whole and Great, and otherwise Useless Parts of the World fertilized thereby, and put into a Condition, from the abundance of their Productions, to communicate their Agreeableness to other People. Here are no Sluices or Mills made use of, which must be yearly maintained at the Charge of the Country, but prodigious Bodies, and vast Mountains discharging those Functions; and which having been once placed there by the Great Director of all things, remain there still without any Expence to those that reap the Benefit of them, being fitted to perform this their great Work thousands of Years, without any Diminution or Attrition. Here are no Artificial Canals or Sluices of a small Extent necessary for this Purpose, but vast Floods of Water, and the greatest Rivers in the World.

Now, since all this is incomparably more Noble and of greater Benefit than that which every one readily confesses to be brought to pass in the aforesaid *Meers* by humane Contrivance and Wisdom; What Reason can these miserable Philosophers produce, to justify their persevering in their Opinions, that the same is here done without any Wisdom?

SECT. XXXV. *Concerning the Temperate Zones.*

AFTER this Torrid Zone *abcd* (*Tab. XVI. Fig. 1.*) there follows two others, one on the one side, *abbg*, and t'other on the other, *cdki*; which in respect of the lesser Heat, as in the Torrid Zone *abcd*, and lesser Cold, as in

the two Frigid Zones, *g p h* and *i m k*; and therefore on account of the greater Temperament of the Air, are called the Temperate Zones.

Taking then *p* for the North Pole, *a b g h* is the North Temperate Zone, and *c d k i* the South; the former of which is inhabited by us, and almost all *Europe*, and the greatest Part of *Asia*, and contains all those Lands and Seas which we may see in the Map of the World, lying between the Tropic of *Cancer a b*, and the Polar Circle *g h*; the South Temperate Zone *c d k i*, which may be likewise seen there, consists chiefly of Seas.

SECT. XXXVI. *The Advantages of the most Northern Parts.*

IT is not necessary to expatiate here more particularly upon the Northern Zone: Every thing about us, or that has been represented in all these *Contemplations*, centers in this, namely, to manifest the Power, Wisdom and Goodness of GOD, which has shined out so brightly in these Parts of the World. This is certain, that in Fruitfulness, in the Temperature of the Seasons, and particularly in the Learning and Understanding of its Inhabitants, it will give place to no other whatever; forasmuch as it is beyond all doubt, that in the Government of its Countries, in Commerce, in Navigations, in the Arts of War, and in an infinite Number of other Sciences, it far exceeds all other People.

But the greatest Benefit of all, and that which incomparably exalts this Zone above all the other Parts of the whole Globe, is, that the Knowledge of the True GOD, and his right Worship, have here their present Seat: Since that this same bright Sun is now set in respect to unhappy *Asia*, GOD having thought these People worthy (which exceeds all Humane Gratitude) to whom he might reveal Himself and his Holy Word, and by them to propagate and diffuse the Knowledge thereof to other Nations.

A truly upright Soul, such as loves and fears GOD, will esteem nothing more detestable, nothing more unreasonable, than to imagine that the Worship of Him also has acquired by Chance, or by a stupid Necessity of Natural Laws, its so just and equitable Principles, worthy of the True GOD, and surpassing all other Idolatrous Worship.

And if an Atheist would but ever have taken the Pains to examine the adorable Wisdom of GOD in this his Word, and the fundamental Knowledge therein of all Creatures; if he would but compare the exact Accomplishment of so many Prophecies with History; if he would reflect upon the wonderful Preservation of the Holy Scriptures, in spite of the Rage and Persecution of great Tyrants and Opposers of the WORD, he will be able to produce very few Arguments to make an impartial Person believe, that it is the Effect of mere Chance that GOD is worshipped in this Part of the World after the manner contained in his Word.

SECT. XXXVII. *The Christian Religion is no Art of Politicians.*

THE Atheists and Infidels have never yet been so Foolish and Brutal (if we may use such hard Words) as to ascribe that Impression which every one has of a Deity or his Worship (how much soever they are disposed to deduce every

every thing from thence) to mere Chance or Fatality. Wherefore being now obliged to seek for other Subterfuges and Evasions, they now refer it to the Arts and Stratagems of great Politicians, who thereby endeavour to keep in awe the People under their Government.

That this has Place in some Pagan Religions, as also in the *Mahometan*, is easy to be shewn, they having been established by the Force of Arms. But nothing is more impossible than to prove the same in the Christian Religion: For if it be the Policy of Rulers and Princes to bridle and keep in awe a giddy Multitude, why has not such Policy, with the Addition likewise of all their Power (whereby they have extirpated Hundreds of Thousands for the Confession of our Lord JESUS CHRIST) been able to suppress a little, contemptible, innocent, unlearned, and defenceless People, nor get the better of those Principles so pernicious to their Atheistical Authority? By which Principles, Men were taught indeed to submit themselves to the Powers that were over them; because there is no Power but of GOD, and because the Powers that be, are ordained of Him. *Rom. xiiij. 1.* But also on the other side, (which is by no means to be endured by an Atheistical Governour, who would direct all things according to his own Pleasure) that Subjects are obliged, in case the Worship and Revealed Will of GOD were opposed even by the mightiest of Monarchs, to deny their Fear and Obedience. Was there ever any Religion better calculated to oppose a Supreme Power, that does not own GOD, like this, tho' in all other Cases it makes the most obedient Subjects? And can any Prince who accounts his Religion nothing else but a Bridle for the People, in any wise endure to hear even the meanest of his Subjects say, with the Apostles, in *Acts v. 29.* *We ought to obey God rather than Man?* Or, will he suffer a Religion to be exercised in any Place under him, where the Founder of it shall give this express Charge to those that exercise it, when persecuted for his Name sake; *Be not afraid of them that kill the Body, and after that, have no more that they can do. But I will forewarn you whom you shall fear: Fear him, which after he hath killed, hath Power to cast into Hell; yea, I say unto you, fear him.* *Luke xij. 4, 5.* From whence an Atheist himself may judge, if all Religions owe their beginning to State-Craft only, whether the Christian would not long before this have been at an End: And since that could not be compassed by so many bloody Persecutions, and raging Cruelties of the highest Worldly Powers, whether the said Religion must not have been preserved from the very Rise of it to this Day, against all the Attempts and Designs of those that would extirpate it, by the Intervention of a much higher and more resistless Power?

SECT. XXXVIII. *Atheists differ from the Wisest Men.*

NOW to return from this Digression to the Business in hand, it is undeniable, that this Northern Temperate Zone is inhabited by the wisest and most learned Men; most of whom acknowledge a GOD and Supreme Director of all Things; from whence it is plain, that the owning a Deity, which has made and preserved all things, is received and maintained by the wisest of all People. If now a deplorable Sceptick, and who still pretends to doubt of these great Truths, will not continue arrogantly to maintain, that the wisest Men are

are the greatest Impostors, and that the less knowing are all cheated, and that he himself is the only wise and righteous Man; he will at least, by comparing all these things together, find a just Cause silently to sit down; and whatever his Philosophy might have taught him before, to enquire farther, whether his persevering in this Conceit, that he is the only wise Man, be not the greatest of Follies; and whether the Proofs made use of by others, to shew that there is a God, are not stronger than those to which he hitherto adhered: Lastly, Whether from the Works of Nature the Wisdom of the Creator may not as justly be inferr'd, as the Skill of the best Workman from those of Art. Which trouble if he please to take, he will have got a great way already, unless he be entirely abandon'd to his own unhappy Principles.

SECT. XXXIX. *Concerning the Frigid Zones.*

THE two last Zones (*Tab. XVI. Fig. 1.*) are those that are called the *Frigid* or *Cold Zones*, of which the Southern *k m i*, lies under the Southern Pole *m*, and seem as yet to be entirely unknown to Geographers; being represented upon their Maps very doubtfully, either by Seas, or by the *Terra Australis Incognita*.

The Northern Frigid Zone *g p h*, especially if one approach pretty near to the North Pole *p*, discovers nothing else but uninhabited Desarts, frightful Rocks, and Mountains of Snow and Ice for the most part; concerning which, the Descriptions of *Nova Zembla*, *Spitsberg*, and *Greenland*, may be consulted.

SECT. XL. *The Impossibility of approaching the Poles.*

ONE can hardly read without Astonishment, what *Kircher* says in his *Subterraneous World*, and which he confirms by a Cloud of Witnesses, namely, as Men approach the North Pole *p*, the Sea is driven towards it with so irresistible a Force, and, as if it fell from a Cataract or Precipice, that many, who have had the Misfortune to come within the said Stream, have been hurried away, Men, Vessels and all, and never seen again; and on the contrary, those who have endeavour'd to sail towards the South Pole *m*, have found the Sea flowing against them with so terrible a Strength, that neither Sails nor Oars could bring them nearer to it.

I leave this Relation to its own Weight: But how little Hope there is ever to discover and to learn the exact Geography under the Poles, may be learn'd from all the Voyagers that have bent their Course that way. Certainly, that in *Kepler's* time, which is something more than a Century, we were ignorant of every thing concerning them, and did not so much as know whether it was Land or Sea under the Poles, is sufficiently shewn by his *Epitome Astronom.* p. 166, and 150. *De Stair* does likewise represent in his *Physiology*, the invincible Difficulties of ever getting thither; saying, p. 487, that when the *Hollanders* endeavour'd to find a Passage to the *East-Indies* by the North, and therefore were obliged to steer their Course towards that Pole, the Compass lost all its Virtue and Direction; by which means all Hopes of advancing farther, seemed to be entirely cut off. Yea, to be convinced that it is still unknown to all Men, what are the Countries lying under the Poles, we need

only cast our Eyes upon the *Cosmotheoros* of Mr. *Huygens*, p. 119. who, in plain words affirms the same, adding thereto, that he may express the Difficulty, if not Impossibility thereof, in the following Wish: *O, if one might but once see these Regions!*

But altho' some might think it possible, that in following Ages the same may be discover'd, yet the absolute Impossibility of ever attaining to the last Degree of Latitude, is daily more plain by new Experiments; the vain Attempts of the boldest Sailors are every time so many new Proofs thereof. But that which seems to frustrate all Hopes, even for the future, are the impracticable and always obstructing Mountains of Ice, which are found there yearly by our *Greenland* Traders, and which, according to all Probability, may date their Age from that of the World; since the Sun seems never to have had so much Strength, as to be capable of dissolving these vast Tracts of Ice, frozen by so many and such long Winters: So that any Access to the Poles will be always defeated thereby, and as long as the Earth continues in the same Position with respect to the Sun, the same Difficulties are like to remain.



CONTEMPLATION XXI.

Of Fire.

SECT. I. *Transition to Fire.*

NOW, tho' we do not, like some Philosophers, assert the Earth, Air, Water and Fire to be the only Principles or Foundation of all Things, nor pretend to limit the Wisdom of the Almighty to a certain Number of Principles, if we may so speak; yet it can be denied by no body, that all of 'em center in the Composition of many natural Bodies: Wherefore we shall proceed to consider this last Element of Fire.

SECT. II. *The Inconveniencies that would befall us, if there were no such thing as Fire in the World.*

IF there be any one still so unfortunate, as not to be able to break loose from those deplorable Sentiments, that every thing that exists, and even Fire itself, has been made by mere Chance and ignorant Causes, at least, without any wife and determinate End: Let such a one retire within himself, and contemplate this Globe of the Earth, and every thing belonging to it, in the State in which he might suppose himself and that to be, in case there was no such thing as Fire.

After the Setting of the Sun, and all other Heavenly Lights (to take no notice here that the Light thereof does even in a great measure consist of Fire,

or brings a great deal of that Element along with it) how does the whole Earth, cover'd with Cloudy and Nocturnal Vapours, differ from the most dismal Subterraneous Caverns and Dungeons? Since during such a time no Man would be able to move one Foot forwards, or to dispatch any kind of Business. Without Fire, which by the Means of Candles, Lamps, Torches, and the like, affords us Light in the greatest Darkness, what difference would there be between our Condition, and that of Men who should be blind half their Life-time? Without Fire, most of the Productions of the Earth, which serve Mankind for Food, for Refreshment, and for Dainties, would not be fit to be used in many Countries to those Purposes, nor could be chewed by the Teeth, nor digested by the Stomach. And every body to whom the way of living, and of preparing our Diet in these Countries is known, must be convinced, that neither Bread nor Flesh, nor most of the Fruits of the Ground, or of Trees, would be of much use without these Means, but would turn to an unwholesome, crude Nourishment, and perhaps to no Nourishment at all.

Would not the dreadful Cold of Winter, if not moderated by Fire, be capable of dispeopling whole Countries, and of freezing to Death numbers of Women and Children, that are not capable of keeping themselves warm by strong and violent Motions?

If there were no Metals for the use of Mankind, (to say nothing of Gold and Silver, which may be the most easily spared) especially if there were no Iron, which furnishes us with so many Instruments for numberless Uses, for Plowing, Building, and in a manner, for all other Arts and Purposes, every one may easily conclude, under what Inconveniencies all Mankind would labour. Now tho' the Iron and other Mines should be infinitely more in number than they now are, yet it is sufficiently known, that without Fire, no Use could be made of them, nor could they be smelted or separated from their respective Ores.

SECT. III. *Convictions from thence.*

TO reckon no more, let an Atheist represent to himself the World in such a Condition, that he and all Men should be without Light in Darkness, without Warmth in Cold, without any Preparation for raw Food, without all the Conveniencies which Metals, and chiefly Iron, would afford them: Now, if any one should come and tell him, that he had discover'd such a Matter by which all these Defects and Wants might be supplied, and the World become happier in so many Instances, would not even the most obstinate Infidel acknowledge the Inventor to be a very wise Person? Now since the same is perform'd by a Being infinitely superior to Man, and after a much more sublime and wonderful manner, why will he refuse to own the Wisdom of such a Being?

SECT. IV. *It is still uncertain what Fire is.*

THERE have not been wanting among the Equirers into the Secrets of Nature, those that have endeavour'd to discover what Fire is in itself, and what are its Properties; and it seems probable that Mr. De Stair, who has

in a manner consider'd all Opinions, has fallen upon the best Notion of it in the following Words; *Explor. VI. §. 1.* There is nothing in Nature more obvious to the Senses, and nothing less intelligible than the Nature of Fire.

SECT. V. *The First Notion concerning Fire.*

TWO Opinions, which are defended with many Arguments by those who maintain them, are at present in vogue; the first is, that all Particles of Matter, of what Nature soever they be, are capable of being turned into Fire, if they can but be moved swiftly enough, or can be divided small enough.

Now, whether such Motion be occasioned by that Fire-Fluid, which the Followers of the famous *Cartesius* term the *first Principle*, or of something else, we shall not here enquire.

SECT. VI. *The Second Notion: Fire seems to be a Particular Substance.*

THE Second Opinion laid down by other Philosophers is, that Fire is a particular Fluid Matter, like Water or Air, which, like those, adheres to many Bodies, and adds something to the Composition thereof.

What sort of Figure the Particles of Fire consist of, we shall not here attempt, as some have done, to investigate; so far as it is not easie to discover the same; nor likewise whether the Chymists have guessed any better, some of whom will have the Essence of Fire to consist in Sulphur, others in an Acid. We shall content our selves with producing the Reasons why it seems most credible, that Fire both has, and maintains its own Essence and Figure, remaining always Fire, tho' not always burning.

SECT. VII. *The first Reason for the aforesaid Opinion.*

TO prove this, the first Reason seems to be, that *all Substances are not combustible.*

How happens it that Wood and Turf will burn, but that the Ashes which they make are incapable of burning? If it be not upon this account, that the Fire-Particles, which were before in the Wood and the Turf, fly away by burning, leaving the Ashes bereft of them, and therefore unfit for burning.

I know very well, that those who are of the foregoing Sentiment, will answer to this, that Ashes and other Bodies, as the *Amiantus* or *Feather-Allum*, and the like, which cannot be burnt by Fire, are of too gross and heavy Parts to be put into Motion by that subtil Matter. But if that were true, it would seem to be a necessary Consequence, that the smallest and lightest Parts would, without Difference, be the fittest and best disposed to produce Fire: But (not to say, that Water might therefore burn, at least much better than Oyl of Cinnamon, Cloves, and others, which being heavier than Water, sink down in it) why don't Volatile Salts burn, which are so easily put into Motion, that the least Warmth is capable of making them evaporate into the Air, and the Parts thereof so fine and small, that no Glass can be shut close enough to keep them always in? And to the end that

that no other Objections may be offer'd on account of the exceeding Finess of their Parts, it is known, that they are so powerful and sharp, that being only dissolved in Water, they will even destroy a Metal as hard as Copper, and turn it into a liquid Matter. They that have a mind to make a Trial thereof, need only put a Copper Farthing into the Spirit of *Sal Armoniac*, in which they will find it quickly dissolved.

SECT. VIII. *The Second Reason; and an Experiment.*

Secondly, IF a very swift Motion were only necessary to reduce all Bodies to Fire, and that a particular and determinate Matter were not required thereto, how comes it to pass, that hot Water being moved more violently by blowing, is not render'd hotter but colder? And yet the Air is so absolutely necessary to our Fires, that without it they would be extinguish'd.

The Truth of this is known even to Women themselves, who for that purpose extinguish their Fire with Covers, or shut it up in Dove Pots.

And to the End, that no body should believe that this way of extinguishing the Fire is not so much owing to the want of Air as to the obstructing the Ascent of the Smoak, whereby it is suffocated; Let a Man make a Tube of Paper (*Tab. XVI. Fig. 2. A B C D*) the Cavity whereof must be a little larger than the Thickness of the Candle *G H*; and let him suddenly put it over the said Candle burning; now if there remains below at *C D*, any Orifice or Opening between the Candle and the said Paper Tube, so as to admit a free Passage to the Air, the Candle will keep its Flame, and remain burning; but if one should compress the Paper at *E F*, so as to obstruct the Passage of the Air, the Candle will be immediately extinguished; notwithstanding that the Tube remained open all the while at *A B*, and allowed a free Passage for the Smoak. [*See this Experiment in the Works of Professor Senguerdius of Leyden.*]

SECT. IX. *The Third Reason, and an Experiment.*

BUT, *Thirdly*, we see yet farther, that the Air likewise is not proper or adapted in all its Parts in general, for the supplying of Fire or Flame, but that certain determinate Parts of the same are required thereto; from whence it likewise seems to appear, that we must form a more limited Notion of Fire, than to think it merely a Motion of some Parts, provided the same be but swift enough, and that it is very probable, that Fire being maintain'd by some particular Substance, does consist of particular Parts, and has therefore a distinct Nature of its own. For which purpose, let any one make the following Experiment:

We took an eight-corner'd Bottle *A D E* (*Tab. XVI. Fig. 3.*) cutting off the Bottom of it, and then put a Candle, set upon a flat Piece of Board, under it; the Ends of which Board *D* and *E* stood out beyond the Edge of the Glass, that they might not be driven up into it when the Glass was let down as far as *B C* in the Water: And we then observed,

I. That

I. That the Candle being lighted, remained burning as in a Lantern, while the Air flow'd in by several little Holes, that it found between the Board D E and the Glass.

II. But putting the Bottle into Water as high as B C, whereby all the Passages for the Air were stopp'd, the Candle burnt about 20 Seconds, and then went out; because the Warmth of the Candle driving the Air out of the Mouth A, the Flame lost its Food.

III. A crooked Tin Tube H K F, which was not very large, being put into the Glass, there seem'd new Air to be derived to it by the Candle; but we found however, that after it had burnt between 21 and 22 Seconds, it went out again.

IV. To see therefore if this did not likewise happen thro' want of Air, which, as it was protruded before the Mouth A, might likewise find its Passage by the other Mouth of the Tube F K H, as soon as it was sufficiently rarified by the Warmth of the Candle, we took a pair of Bellows L H, blowing continually fresh Air therewith into the Tube, and by the Tube into the Bottle; whereupon we observed the Candle burning as bright as ever before, whilst such blowing lasted.

V. But that which is very remarkable, was, that when instead of the Bellows we blew into the Tube at H, with the Mouth, some Air which had been a while in the Lungs, we found the Candle did not burn above 10 Seconds; and consequently not near so long as when it had no fresh Air at all. This is a plain Sign that the Air in our Lungs loses that Property which render'd it fit to feed the Flame, and that Flame and the Breath of Men seem to require the same kind of Air.

VI. This is the more confirmed, forasmuch as when we suffer'd the Air to go no further than the Mouth, and not to descend into the Lungs, and by quick and frequent Breathings, convey'd the same into the Tube, the Candle would continue burning, tho' not so bright as when we used the Bellows, which supplied it with more and fresher Air.

VII. Having put a little Wax-light in the Place of the Candle, we found that by leaving the crooked Tube in the Bottle open, the said Light burnt 170 Seconds.

From all which it may be inferr'd, with great Appearance of Truth, that the Air in general is not only necessary to Fire, but even that some particular Parts thereof are not only proper for it; and consequently, if it be not easy to prove, yet it is very probable, that Fire is likewise a particular Substance or Matter. For if it had wanted nothing more than that fine Element or Principle, which some Philosophers have supposed, and besides them only some coarser Particles, be they what they will, so that they could by the said Matter only be continued in Motion, it does not seem that either of these were wanting here, even at the time when the Candle was extinguish'd. For of the latter sort there was enough remaining in the Candle itself; and according to these Philosophers, the other fine Matter may with less Resistance come at the Flame through the Pores of the Glass, than through the Air itself. Is this likewise by Chance, that whereas Fire

does

does stand in need of a continual Afflux of particular Particles of the Air, the said Particles are always at hand, and are endowed with just such a Property as will feed almost all kinds of Fires? How comes it then, that they dare not likewise maintain, that the Fitness of the Teeth and Pinions of a Wheel, a Clock, or a Mill, or the Wards of the Key for a Lock, which it is to open, are formed without the Contrivance of the Workman? Since the Ends and Purposes for which they are used, fall infinitely short in comparison of those great Benefits which the Aptitude of Air and Fire to each other do derive to Mankind.

SECT. X, and XI. *The Fourth Reason, and Experiments.*

IF now, *Fourthly*, we can shew by Experiments, that that which we discover in Contemplating Fire has a great Analogy and Likeness to the Effects of Water and Air, with respect to the Matters that are dissolved therein; we shall learn farther, that those Philosophers seem to come nearest to the Truth, who maintain, that Fire is a particular Matter, or a *Menstruum*, as the Chymists phrase it, capable of unbinding, that is, of dividing or separating very many and almost all Bodies that are known to us; after the same manner, for instance, as Water acts upon Salt, and Aquafortis upon Iron: So that the burning of most Bodies is no otherwise perform'd, than by the melting of some of the Parts thereof in the Flame. For which reason, if there be many Fire-Particles in such Bodies, as Wood, Turf, or the like, they help to encrease the Flame when they are let loose by burning; and when none of these are to be met with in Bodies, or when they can't be unbound, the Flame is not encreas'd thereby, but those Bodies are only melted and render'd fluid in the same manner as we see Ashes and Metals melted in the Fire, which don't burn, but are turned to Glass. And as other *Menstruums* do either not dissolve some Bodies wholly, or not in a long while; so we find some, but very few, Bodies that are capable of resisting the Power of Fire after it has long operated upon them.

Those that desire to see some Examples of this kind of Effects of Fire, need only consult the Writings of Chymists about them; and to save them trouble, we shall present them with some few.

'Tis known, that if one put Salt of Tartar and pounded Antimony in Water together, that Salt will take hold of the Antimony in a little time, unite itself in that *Menstruum* with the Sulphur thereof, as the Chymists delight to call it. After the same manner we find, that the said Salt of Tartar unites itself with the Sulphur of Antimony when dissolved in Fire, as before it had partly been in Water. Now the said Chymists know, that whether Fire or Water be chosen for a *Menstruum*, a Mixture of the same Properties will result from this Salt and Antimony; and every one may see the same by putting Vinegar to both.

Thus we see the same Effects resulting indifferently from Fire and Water in other Chymical Operations; such as Coagulations or Precipitations, as they are called by Chymists; the *Regulus Antimonii* being mingled with its Sulphur in Antimony, by the means of Salt of Tartar, that unites itself in the said Sul-

phur,

phur, is separated from it by Fire, and sinks to the Bottom after the same manner as Steel united with the Sulphur-Copperas, when this last is dissolved in Water, and so in many other Cases.

Thus we find also, that the Flame of a Candle is always blue and transparent at Bottom, but much whiter at Top, because more Parts of the Cotton and Tallow are there mingled in the Flame, which is render'd thicker thereby; just after the same manner as when any thick Matter is mingled with the Water, which will be clearest where there is a less Quantity of such Matter, and thickest or most troubled where the Matter mostly abounds. So likewise, when you kindle a Brimstone Match, the Flame proceeding from the Brimstone will appear at first blue and transparent, but so soon as the Stick or Card, which it cover'd, are dissolved, the Confusion of the Parts of both Bodies will render the same thicker and whiter presently.

Infinite Examples of the same kind might be produced to shew the like Effects of Fire, and the Flame thereof, as do occur in other *Menstruums*, which may also be observed in the Turf of this Country, and many other combustible Matters. Thus is Flame tinged blue or greenish, like *Menstruums*, by Copper, as it is upon this Principle that the Engineers understand how to give different Colours to their Fire Works. This seems yet farther to confirm what we have said above, namely, That Fire is to be accounted a fluid Matter, and like other Fluids, to consist of particular Parts.

SECT. XII. *The Fifth Reason, and several Experiments.*

Fifthly, IF it be thought, that it has been justly concluded, that the Air is a particular Fluid, consisting of its own determinate real Parts, only because it had an Elastick Faculty (whereas several, according to a Philosophy embraced at this time, maintained the same to be nothing else but a Collection of all kinds of Particles) why should not the same Arguments be as conclusive to hold the same of Fire too? Seeing that the Parts thereof, when put into Motion, do expand themselves with much greater Force than those of the Air. An Example of such an Expansion of Fire mingled with Water, may be seen above in *Contemplation XIX*. But a more common Proof of the unspeakable Greatness of this expansive and rarifying Power of the Fire, may be fetch'd from the modern Mines, Mortars, Cannons, and other kind of Artillery, which, in the blowing up of such strong Walls and Bulwarks, and in the amazing swiftness of the discharg'd Bullets, do represent to every one the dreadful Force of the rarifying Faculty of Fire; for it is now well enough known, that these Effects (scarce to be believed by such as had never seen them) are only produced thereby.

It was with Amazement that I read the Experiment of Mr. De Stair; having omitted to make the same myself, because the Glasses belonging to the Air-Pump, and which are wanted for that purpose, cannot be so easily procured in this Place: He says, in his *Physiolog Expl. XIX. §. 121.* that upon heating Red-Lead in a Glass, from whence the Air was exhausted by the Rays of the Sun collected in a Burning-Glass, the Glased Vessel in which the said Red-Lead was contained, burst in Pieces with a great Noise. Now
he

he that knows, *First*, that this Read-Lead consists only of the Ashes of burnt Lead, upon which a continual Flame has long acted; and, *Secondly*, that the said Lead-Ashes become heavier by the Operation of the Flame, and therefore is impregnated with a great many Fire-Particles, that join themselves to it (since there comes out a greater quantity of Read-Lead than there was of the common Lead put into the Fire) can he judge otherwise, than that these Fire-Particles being excited and put into Motion by the Fire of the Burning-Glass, dilated themselves, and thereby burst the Glass? From this Experiment, since the Glass was first emptied of Air; and from the first Experiment of Water, it seems that it may be infer'd, that it is not always necessary to call to our Assistance the Force of the Air, which is present in Mines or in Guns, in order to understand the rarefying Force of the kindled Gun-Powder, since here the whole seems to be ascribed to the Particles of Fire.

The same seems to be confirmed by the additional Experiments of Sir Isaac Newton's Treatise of *Optics*, p. 354. where it is said, that upon distilling a Spirit from Oil of Copperas and Salt-Petre, and pouring the eighth Part of an Ounce thereof upon half as much Oil of Carraways, in a Place from whence the Air was exhausted, the Mixture presently took Fire, and burst in Pieces a Glass that contained it, of six Inches Breadth, and eight Inches Heighth, just like kindled Gun-Powder: This can by no means be ascribed to the Air, because the Glass was emptied of it; wherefore the rarefying Power of the Fire must be consider'd as the Cause thereof.

SECT. XIII, and XIV. *The Sixth Reason, and an Experiment.*

FROM what has been said above, about Read-Lead, it seems, that one might infer, that as Air and Water are consolidated with Plants and Living Creatures, and help to compose the Bodies thereof, the Particles of Fire are in the same manner to be found in the Structure and Composition of many things, without any actual Burning, as Water may be in hard Horns, Bones and Wood, without rendring the same Soft or Moist. This the Chymists can witness, who have frequently distilled such Bodies, without mixing any Liquid Matter with them.

They who have ever seen how easily many Things burn, and how with a touch of the least Spark of Fire, they are in an Instant turned almost all of it into a dreadful and destroying Flame, will perhaps insist upon no other Proofs, to be convinced that there are lodged in Wood, Turf, Bones, Oil and Gun-Powder, a vast Number of Fire-Particles, which as soon as kindled, do all of them operate; whereas without being kindled, they remain quiet and without Motion.

But for a plainer Proof how probable it is that Fire itself may contribute to the Formation of solid Bodies, the Naturalists know, that there has been lately in the foregoing Age, a certain Substance disclosed to the World, to which they give the Name of *Phosphorus*: This appears to be a solid hard Body, that may be handled; but put it into warm Water, and it will assume any Form, and retain it after 'tis cold: So that the Makers thereof use

this Method, to collect a great many small Balls, in which Shape it oftentimes comes over first, into one great Piece. Now, that this Matter, if not wholly, yet for the most part consists of a still Fire, is plain from hence; that if you let it lye for Years together in cold Water (as a great Quantity thereof in my Custody has lain so above ten Years) it will not burn; but being taken out of the Water, the Warmth of a Man's Hand will presently produce a Light in it, and a Flame too, tho' not sensible; and if you spread a little of it upon the Skin of your Hand, it will seem as if a little Flame rose from it, but without burning: But if you encrease the Warmth of this *Phosphorus* a little more, it will presently exert its Heat, and be changed into a consuming and unextinguishable Fire, burning till nothing hardly remains of it, excepting, as some say, a little sowre Liquor. I never burnt it in a great Quantity, but have found by Experience, that the Warmth of the Sun will kindle it; and that when one rubs it hard upon a Cloth, the same will take Fire; as likewise, that when some Body had smear'd his Face over with it, that he might shine in the dark, and afterwards moving so much as to get a kind of a Sweat, it burnt all the Hair off his Head, and had like to have occasion'd much greater Mischiefs. But we shall speak more largely hereafter concerning this *Phosphorus*.

But that besides all this, Fire joins and fixes itself to many Bodies, has been plainly enough prov'd by Mr. Boyle's Experiments: and it is affirmed by many, that the Beams of the Sun collected in a Burning-Glass, and pointed for a time against Antimony, have encreased the Weight thereof.

Yea, since Fire as well as Water, Air and Earth, have been upon Enquiry, found in the Compositions of all Animals and Plants, what Reason can any one alledge, that the three last should be esteemed particular and determinate Beings any more than the first? We shall not reckon the other Properties of Fire, since this seems sufficient to prove, that it is a very particular Matter, at least that it is very probably so.

SECT. XV. *Convictions from the foregoing Observations.*

Now, whatever the Nature of Fire may be, can any one ever fancy, with perfect Tranquillity, that so noble a Creature is found in the World by Chance, and without Design? The Beauty whereof is so great, that whereas the Ingenious Painters can imitate the Colours of all things, they are only unable to represent the Glance of Fire; the Benefit of which is so universal, that without it, the World would be deprived of Warmth, of Light, of Fertility, and be nothing but a dismal Solitary Habitation for those that dwelt upon it; even so far, that there is hardly any thing to be found in the World, the Preparation of which for the Use of Mankind, is not wholly, or for the most part, owing to Fire. Not to mention the illustrious Use thereof, by which the Enquirers into Nature have made it, as it were, one of the chiefest Keys wherewith to unlock the most hidden Secrets of Nature. Yea, if Fire has its Existence by Chance, how can any one who believes it, deliver himself from the dreadful Apprehensions, that either by the same Chance, or by an unavoidable Concurrence of ignorant, but necessary, Causes, the

the World may to morrow, or sooner, be deprived of Fire, and he himself condemned to perpetual Darkness, and to a most miserable Condition?

SECT. XVI. *The great Quantity of Fire in the World.*

Now if one of those Philosophers, who unhappily doubts of the greatest Truths, be forced to acknowledge, by what has been said above, that hardly any Living Creature can subsist without the use of Fire; let him go on and observe, what great Abundance of it is to be found every where; and how being at hand in almost all Substances, it does as it were offer itself to the Service of all Men, and is found ready, without their taking hardly any trouble about it.

To shew that this is true, it will not be necessary to search for Demonstrations, nor a long Chain of Arguments in the Depths of Philosophy. We know well enough, that it is to be met with in a manner every where; as in almost all Plants, especially such as consist of Wood, and which compose whole Forests; in the most part of Animals, in their Bones, in their Flesh, in their Blood, all which being dryed, will burn; in so many Minerals, in Fenny Grounds, in Coals, in Brimstone, in Salt-petre, yea even in Stone itself; all which Mankind are wont to make use of after so many Ways, when either their Profit or Pleasure require it.

SECT. XVII. *The Wisdom of Him that restrains the Power of Fire.*

Now if all this cannot induce an obdurate Atheist to acknowledge either Wisdom or Design in the Creator, or Goodness in the gracious Giver of this Fire, let him contemplate the vast Quantity thereof that is found in the World, and the terrible Powers of the same: And then let him tell us, whether he cannot therein discover both the Wisdom and Power of Him who preserves the Earth from being destroyed by Fire; since so raging a Matter that is to be met with in such great Plenty every where, is after so wonderful a manner bridled and restrained from exerting its consuming Faculties, and yet so readily offers itself to the Service of every one that wants it.

That this is not a vain Imagination, is as clear as the Day; because there is not only a Quantity of Fire sufficient for all Purposes throughout the World, but even so much of it, that no Body could think thereof without Horror, if he were not assured that there were not an over-ruling Power that holds the same in his Hand.

SECT. XVIII. *An Historical Account of Fire in the Earth.*

MOREOVER, if we look upon the Earth, how can we avoid being alarmed, when we find so many Parts of it filled with Fire! In our watry *Holland*, and even in the drained Meers and Fenns, Experience has frequently taught us, that the Vapours exhaling from the Pits and Wells of the Peasants, having been accidentally set on fire by a Candle, have miserably consumed both Men and Houses.

But to be yet further convinced of the Danger in which the whole Structure of this Globe is, according to all Probability, on account of the Quantity

and devouring Faculty of the Fire hid in the Bowels of it, we need only consult History concerning the number of subterraneous Caverns of Fire and burning Mountains, in which a natural Gun-Powder, if there be not yet something more violent, does so often exert itself in all its dreadful Effects. From whence otherwise do proceed the terrible Eruption and Eruptions of Fire of the famous *Monte Gibello*, or *Ætna*, in *Sicily*? By the Force of which, Stones of 300 *lb. wt.* have been thrown out to the Distance of several Miles, and whole Rivers of Fire flowing out of it, have consumed every thing round about it. In the Year 1557, it occasion'd an Earthquake throughout the whole Island, with the Destruction of many of the Buildings, whilst Noises, like the Discharges of the greatest Guns, were heard, and rent the Earth; thro' the Openings of which the Fire burst out in such great Quantities, as to destroy every thing five Leagues about this Mountain. This great burning Mountain, according to the Account of *Borelli*, does contain in Circumference at the Foot or Bottom of it, about an hundred Leagues; and there might be a whole Book writ upon the dismal Effects of it.

Had this been the only Place of the World where such a thing had happen'd, our unhappy Philosopher might still have been easie, flattering himself, that it was an uncommon Event, and that there was no Danger from thence to the whole Earth: But he won't be so easily comforted, when he finds in the Relations of all Geographers, that the like burning Mountains are to be met with in all the Corners of the Earth.

The *Monte di Soma*, or *Vesuvius*, lying not far from *Naples*, is both now, and has been for many Ages a *Volcano*, or burning Mountain; as is *Hecla* in *Iceland*, which rages oftentimes no less than *Ætna*, vomiting out prodigious Stones with a terrible Noise.

In the Island of *Java*, not far from the Town of *Panacura*, a Mountain broke out in the Year 1586, for the first time discharging such Quantities of burning Brimstone, that above 10000 Persons in the Country round about were destroyed therewith, and casting out great Pieces of whole Rocks as far as the said Town, accompanied with so dismal a Smoak, that the Sun was cover'd with it, and the Day almost turned into Night.

The Mount *Gonnapi*, in one of the Islands of *Buada*, that has been burning about seventeen Years, broke from the rest with a terrible Report in the Month of *April*, of the said Year 1586; throwing out a most dreadful Quantity of burning Matter, and great Red-hot Stones, of the length of a whole Fathom, as they were found in the Sea, besides such a prodigious Number of the smaller Sort, that they render'd the Sea, in a manner unfaillable, whereby the Fish were suffocated, and the Waters boiled as if they were in a Kettle with Fire under it.

There is likewise another Mountain upon the Island *Sumatra*, which smoaks and flames just like *Ætna*.

The Earth in the *Molucca* Islands casts out Fire in several Places, and frequently with a hideous Noise, especially a Mountain in *Ternate*.

In one of the *Moorish* Islands, lying 60 Leagues distant from those of the *Molucca*, there happen very often Earthquakes, with Eruptions of Fire and Ashes;

Ashes; and those subterraneous Fires have so great a Strength, that they cast out glowing Stones, which appear like whole Trees; and the Rocks themselves are thereby burnt and consumed; whilst the Mountain which represents a frightful Flame, roars with a terrible Noise, as if there were a continual Thunder, or Discharge of the greatest Cannon.

In *Japan*, and the Island about it, there are many little, and one great burning Mountain.

In *Tandaja*, one of the *Philippine* Islands, there are found many small Fire-Mountains; and one in the Island *Marindica*, not far from them.

The like are found in *North America*, in the Province of *Nicaragua*; as also in *Peru*, among those Mountains that make the Ridge of the *Cordillera*, near the City of *Arequipa*, there flames a Mountain continually, which causes the Inhabitants to live in a perpetual fear, lest it should burst some time or other, and swallow up the Town. There is likewise one near the Valley *Mullahalo*, which being open'd by Fire, did cast out great Stones, and by the Cracks and Noise that it made, put even very distant People into a terrible Fright.

There be also several burning Mountains in the District that lies on the East-side of the River *Jeniscea*, in the Country of the *Tongesi*, some Weeks Journey from the River *Oby*, according to the Relations of the *Muscovites*; as also near another Water called *Besida*.

They who desire to be farther informed of these, and other Places of the World, where Fires have formerly appeared out of the Earth and Mountains, may consult the Cosmographers and Geographers, such as *Varenius*, &c.

That which is related in the History of the Royal Academy of Sciences for the Year 1708, is particularly remarkable, namely, that near the Island *Santorini*, in the Year 1707, there sprung up a new Island from the Bottom of the Sea, in which, about the End of *August*, the subterraneous Fires, which at first made a terrible rumbling, burst out at last with such violent Noises, as if six or seven Pieces of great Cannon were discharged at the same time, and made continually new Rents and Openings, through which sometimes a great Quantity of Ashes, and sometimes so vast a number of little glowing Stones, were cast up into the Air, that they made a little Island near that of *Santorini*, where they frequently fell down, making it appear as if it were all on Fire: Besides that, there were frequently seen huge burning pieces of Rocks tossed into the Air like Bombs and Carcasses, with such a Force, that they were carried seven Miles before they dropt into the Sea. The rest of these terrible Circumstances may be read in the above-mention'd Place.

SECT. XIX. Fire in the Air, and an Experiment.

Now if we pass from the Fire of the Earth to that of the Air; must not even the most obstinate Atheist acknowledge, that this Element is likewise full thereof; in case he ever saw the same disturbed and put into Combustion by Thunder and Lightning, and the dreadful Effects thereof? But sup-

posing

posing it to be in the midst of fine and calm Weather, and a bright Sun-shine, yet even there could he not reflect, without trembling, upon the great Quantity of Fire wherewith he is surrounded, especially if ever he had an Opportunity to observe the Effects of great Burning-Glasses, which (by only collecting the Beams of the Sun into a Place so much smaller, as the Focus is smaller than the Superficies of any such Burning-Glass) can kindle a Fire of so terrible a Heat, that in a few Minutes it will do that which our greatest Fires are not able to do in Hours, Days, yea, Months and Years, of which more largely in another Place. But to shew here, that the Air even warmed with a Kitchen Fire, acquires a sufficient Quantity of the Heat thereof to do harm, one need only take a polished Silver or Pewter Spoon, and put the Cavity of it against the Fingers, and hold it fast with the Thumb, in such a manner that the Handle of it may stick out about half way above the Forefinger. Now if you hold the back of your Hand, and the Concave part of the Spoon against the Fire, so that the Appearance, or Image of the Fire collected therein, throws a bright and enlighten'd Spot upon the Forefinger, you will find, that the Fire which is in the Air, being reflected from the Cavity of the Spoon upon the Finger, will burn the same intolerably, even whilst the Hand suffers no Inconveniency from the Fire itself and the Air about it, and is only sensible of a moderate Heat.

But to be entirely convinced of the great Quantity of Fire in the whole Universe: Let any Body view with Attention the Sun and the Stars, which do not only shew themselves to us thro' Telescopes, but even to our naked Eye; and let him consider, what a vast Quantity of Light descends from them to us, which is either plain Fire itself, or at least brings along with it the most subtil Fire imaginable: And then ask such a one, whether he be not convinced of the Probability of what we have said, and particularly of this, that the Heavens likewise do contain Fires, the Number of which exceeds all Conception.

SECT. XX. *Convictions from the foregoing Observations.*

Now to come to a Conclusion of all these Matters, let a Man seriously consider with himself all that has been just now related concerning the Fires in the Bowels of the Earth, or those of the Air and Heavens, and let him tell us, since the Property of Fire is such, that when once put into Motion, it will kindle every thing that is capable of being burnt or inflamed, and wholly destroy the same, whether it does not appear a greater Wonder to every one that argues rightly, that the Earth, with all about it, is still subsisting, than that it has not long since been entirely devoured and consumed by so many Fires as are in and round about it. Certainly, if the Volcanos, or burning Mountains, that are to be found in all Corners of the World, had a Communication with each other by subterraneous Rivers of Fire (as many think may be proved by History and Experiments) it is hardly conceivable, that it could have continued in being to this very Day.

And consequently, that which the Christians confess, and St. Peter maintains in his Second Epistle, *ch. iij. v. 7, 10, 12.* does not deserve to be so much

cavill'd at and derided, as is done by some Atheists, namely, *That the Heavens and the Earth which are now, by the same Word are kept in Store, reserved unto Fire against the Day of Judgment and Perdition of ungodly Men.* — in the which the *Heavens shall pass away with a great Noise, and the Elements shall melt with fervent Heat; the Earth also, and the Works that are therein, shall be burnt up.* He repeats the same in the 12th Verse: *Looking for and hasting to the coming of the Day of God, wherein the Heavens being on Fire, shall be dissolved, and the Elements shall melt with fervent Heat.* Since Nature, and the dreadful number of so many terrible Fires that are found almost every where, in the Heavens, in the Air, in the Body of the Earth, and almost in every thing that it produces (as has been shewn before) ought to make every one believe, that the Destruction of all things by Fire, has long been at the Door; and that it is a certain Miracle, that the World has not sooner felt the Effects thereof.

SECT. XXI. *Convictions from restraining the Power of Fire.*

BUT after all this, add yet something more, by which a Divine and Overruling Power is as sensible, as if it were felt by the Hand: Can any one imagine, that it is by mere Chance, and without Wisdom, that so terrible a Creature, which by one single Spark can be put into Action, and into the most violent Motion, is bridled and curbed from doing Evil, and moreover compelled to be beneficial to Mankind in innumerable Manners, and infinite Occasions; and that there is no Direction necessary thereto, to prevent the same from putting the whole Globe into a Conflagration, as it sometimes does several Parts thereof? Can we here discover no Goodness nor Wisdom of a Great, Mighty and Gracious Ruler, since by his Power only this raging Matter is, as it were, imprison'd in Pitch, Oil, Brimstone, and whatever else is a proper Food for it; and that He does not suffer it to break out to the entire Destruction of all Things: That besides this, He does deliver to Mankind the Keys of these Prisons, which can at any time set free this tamed and chained Prisoner, and set it at full Liberty, only by rubbing one piece of Wood against another, by striking Steel upon a little Stone, by putting a very small Quantity of Fire to other combustible Matters, and in short, after infinite other ways, as often as the Service thereof is necessary? Again, if the bridling all this Fire is brought about by Chance, how can any one remain without a continual and deadly Fear, lest by the same Chance, which is no more determined to one Object than to another, this imprisoned Fire might shake off its Fetters, and so produce a most miserable Destruction, in the most dismal manner, of every thing that stands in its way?

Let now a Philosopher, who will not admit of this, in order to be convinced, step once into a Magazine of Gun-powder, where a great Quantity of that Matter is laid up: Now if Experience had not taught him beforehand, would he have easily believed, that in such a black and unsightly heap of Grains, such an unconceivable and dreadful Quantity of Fire were hid and lock'd up, in which he could neither discover Light, nor Warmth, nor any sort of Motion? and yet, by the fall of a little Spark of Fire into this seeming unapt Matter, it would be in an instant of Time turned into a consuming

suming and destroying Flame, the Violence of which would render the Earth, and cause even remote Houses and Walls to fly up in the Air, and fall down in Heaps of Rubbish; insomuch, that the strongest Towers, nor even Rocks themselves, how solid soever, would be able to resist the Force thereof.

And to the End that our Philosopher may not flatter himself with this poor evasive Comfort, that there are but few Magazines of such destroying Matter, and that but few People have occasion to come in the way of 'em, let 'em consult the modern Writers of Natural History; or let him only consider with Attention, the Experiments and Relations of the present and past Years; and then the vast quantity of Thunder and Lightning, and the frightful Eruptions and dreadful Havock made by so many Earthquakes and burning Mountains, and he will undeniably be convinc'd, that it is not only in the Magazines or Mills of Powder, that he is to apprehend the Effects of Brimstone and Salt-petre, which are the Ingredients of Gun-powder; but that likewise the Air and the Earth, if they be not full of a natural Gun-powder (as some Philosophers, and not without Reason, have thought) are at least endowed with so violent and dreadful a Fire, that the Effects of it does not only equal those of Powder itself, but in innumerable Cases does incomparably exceed it, altho' it so often appears entirely inactive.

SECT. XXII. *After what Manner the Fire of the Air and Heavens is preserved.*

Now if that Fire which is imprison'd upon the Earth in so many Places, and in such various Bodies, and hinder'd from breaking out for the Destruction of all things, does discover a great and mighty Preserver; so that even an Atheist cannot or dare not promise himself one Hour's Security, if it were not an all-protecting Providence, but only unknown Laws of Nature, or mere Chance, operating indifferently this or that way, that interven'd: How much more then is a Wonder-working and an Adorable Power visible from hence, that such an unconceivable Quantity of Fire can be kept up in the Air round about us, without putting every thing into a Conflagration! And not to speak of Lightning again, is it not demonstrable by the modern Burning-Glasses, that Light itself, as it is derived to us from the Sun, being a little more closely compress'd or collect'd, would be capable of converting the whole Globe (nothing excepted) into a glowing Ocean, much more dreadful than that which is seen in the Glass-Houses, or in the Metal Smelting-Houses

Now I first ask those People that cannot discover in all this a Divine Direction, to what Cause 'tis owing, that the Globe of the Earth is placed and still continued at just such a Distance from the Sun, so that the Fire thereof can only warm, enlighten and fertilize the same? And how it happens, that it is not removed to so great a Distance, as to be render'd entirely barren by Cold, or brought so near to the Sun, as to be burnt up and turned into a glowing Heat thereby; since it is plain enough, that nearer to the Sun the Light is more closely compress'd in the same Space, and consequently has much greater Force in burning? And whether it be conceivable, that

that among so many Millions of Places that might have been possess'd either by the Earth or by the Sun, in the vast space of the Universe, there is just one single Point chosen, where only it is most advantageous to this our Globe, without any End or Design?

Secondly, Since if the Light came down to our Globe so closely compressed as it is near the Sun, the Earth would undergo a much stronger and more violent Heat than what we observe in the Focus of great Burning-Glasses, wherein, in the Space of a Minute, all kind of Metals fall down in glowing Drops; let these Philosophers tell us, whether any more proper Means could have been imagined by them or others, to secure the Earth from so dreadful a Heat, than to bind the Light to such Laws, by which every thing that proceeds from one Point, is dissipated and scatter'd; inso-much, that the Right Lines, which it describes by its Beams, the farther they flow from their Source, the more distant they become continually from each other. This Dissipation or Scattering of Light, the Mathematicians express by the Term of *Diverging*, and they prove the same by numerous Experiments, by which, besides that, as we have said above, the Earth is preserved from the most dreadful Conflagration: This great and unvaluable Conveniency is conveyed to Men, that all things, and one and the same Point of many, may be seen at the same time on all sides. Of all this, those who have no Skill at all in Opticks, may for greater Clearness consult what has been said in *Contemplation XII.*

SECT. XXIII. *Convictions from thence.*

AND can these unhappy Men still fancy that there is neither Wisdom nor Power in all this; to wit, That all the Rays of Light which is derived down to us from so immense a great and fiery Ball (as we may suppose the Sun to be in all appearance) do sufficiently *Diverge*, or are scatter'd abroad, before they reach this Earth; and that it is without any Design, and only by meer Chance, that so active and violent Matter as are the Particles of Fire, which if press'd together, or united in a Point, would, as in a Furnace, turn all things into a glowing Sea; and notwithstanding its being continually protruded with so swift and terrible a Motion, is yet so strictly bound and confined by these Laws of *Divergency*, and continues so, that it has never departed from them in so many thousand Years following; and that all Men whatever, can enjoy nothing but the greatest benefit therefrom, altho' its dreadful Motion produces otherwise nothing but general Destruction.

SECT. XXIV. *All the Water in the World not sufficient to extinguish this Fire; shewn by several Experiments.*

THERE remains still to remove one Subterfuge, which seems still of use to those that deny a Divine Providence, namely, that how plentiful and how terrible soever the Fire may be which is found in and about the Earth, there is yet a sufficient Quantity of Water to preserve the same from being burnt; so that upon this occasion, it does not seem necessary to ascribe such a Preservation to a particular Favour and Foresight of God.

I shall not object to this, that there are even such Bodies containing such Fire-Particles within them, that can only be put into Action by Water, of which a Lime-Kiln and Mill, not many Years since, has been a sad Example, which by the breaking of a Sea-Dyke, and overflowing of the Water till it reached the Lime, was entirely burnt down: Besides, many other Instances that may be brought from Chymistry, to prove, that a cold Matter infused in Water, will become intolerably hot, and sometimes break out into a clear Flame: Thus Oil of Vitriol, upon putting cold Water to it, will make the Glass in which they are mingled so hot, that one shall not be able to hold it in ones Hand: The same will likewise happen, by pouring cold Water upon that which remains from the Sublimation of the *Lapis Hæmatites* and *Sal Armoniac*, and in many other Cases.

But it is an Experiment known to the greatest Enquirers into Nature of this Age, that Living Sulphur, mixed with Filings of Iron, and kneaded to a Dough, by the addition of cold Water, will in a few Hours time become warm, and at last be set on Fire; touching which, the *Physicks* of Mr. Hartsoeker, the *Opticks* of Sir Isaac Newton, as also the Registers of the Royal Academy of France, may be consulted.

Now, whether this be one of the Causes of the Subterraneous Fires, Earthquakes, and the like Motions, we shall not here nicely enquire into; but at least it is unquestionably true, that there are Matters of such a Nature in the Earth, which, far from being secured from burning by Water, are kindled thereby, and compleatly set on Fire.

And to shew farther, that there are also certain Matters which are capable of burning in Water itself with great violence, without being able to be extinguished any wise thereby, we need only cast our Eyes upon that sort of Fire-Works, which first performing their Operation under, and then above the Water, do thereby represent an unextinguishable Fire. To this purpose, I find this little Experiment in my Notes, of the 29th of Octob. 1695. We took a little Cartouch, or Case, of that kind which they use in making little Serpents or Squibs in common Fire-Works, and filling the same with Dust of Gunpowder, without adding to it the Cracker or Bounce with grained-Powder, we tied it to a little Stone; then it being kindled, and dropt into a Glass filled with Water, we observed it to burn under the Water, and in the Dark of the Evening, to give a great Light.

Now, since there is in the World much Brimstone and Salt-petre (of which Gunpowder does partly consist) when they have once taken Fire, they cannot easily be extinguished by Water, which does sufficiently appear from what has been just now said, as it does likewise from the frightful Eruptions of the Subterraneous Fires, which have oftentimes burst out from the bottom of deep Seas; of which we have given an Instance before, in the Case that happen'd not long since, of the new-born Island near that of *Santorini*.

SECT. XXV. *Some Experiments about the Phosphorus.*

BESIDES the foregoing Experiments, the restless Curiosity of Chymists enquiring into the Nature of all things, has some few Years since revealed to the World a sort of Collection of Fire (of which we have already made some mention above) called the *Phosphorus*, which seems to be before scatter'd in the Air, and oftentimes in Water itself, and being prepared by the accession of any Heat, may be reduced into a perfect Flame: Among several Experiments which we have made about this *Phosphorus*, I find the following upon my Notes;

I. That it has been often found, that a certain degree of Warmth was necessary to make the *Phosphorus* yield a Light or Burn:

For in the Winter, or *January 1696*, a little bit of it upon a Paper, lying upon the side of the Glass-Receiver of the Air-Pump, in a place that was not warm, was observed to give no Light; but on the contrary, some of it being put upon the Hand, it presently shined and flamed, but without doing any hurt. The same being repeated several times, always produced the like Effects. But being put into a little Bottle, that was made somewhat warm, it did not only burn, but remained burning, tho' the Air was quite pump'd out of the Recipient, into which it was put, and also afterward, when the Air was let in again: So that it appeared from thence, that this Fire, different from many others, would equally burn with or without Air.

We likewise saw that the same *Phosphorus* being put upon the Dust of Gun-powder, and held in a Paper at such a Distance from the Fire, as a Man may hold his Hand without uneasiness, both of 'em presently took Fire: The same happens whether you use the Dust of Gun-powder, or the round Grains of it with *Phosphorus*. From whence the foregoing Assertion, *viz.* that Warmth was necessary, does likewise seem to be proved: As likewise from hence, that upon rubbing the *Phosphorus* upon brown Paper, and warming the same, it will burst out in a perfect Flame.

II. In another Experiment, we took some of the finest Parts of Dust of the *Phosphorus* (which in the Distilling are drawn over together with the rounder and larger Pieces) and put it into a little Vessel, with Water upon the Fire; where after it had boiled, we perceived, that in the empty Part of that Vessel, there appeared a great Light at the Top of the Water, and some little Pieces, as if they were burning, floated upon it.

From hence it is plain, that these Fire-Particles, with the requisite Degree of Heat, will likewise burn in Water; and that Fire can also pass thro' Water, and produce a Flame upon it, without being extinguished therewith: It can't be objected, that there are not sufficient Pores or Passages in the Water for it, since in the foregoing Experiment, *SECT. XXIII.* when the Gun-powder burnt in the Water, a thick Smoak ascended, as passed thro' the whole depth of the Water.

III. We put the Water, in which the said Dust of the *Phosphorus* was boiled, into the Recipient of the Air Pump, and observed that some of the small luminous Particles preserved their Light till the Glass was almost evacuated

cuated of Air ; we likewise saw, that every time that the Air was pumped out of the Recipient, a great Light rise out of the Bottle that held the said boiled Matter : From whence, as well as from other Experiments, it seemed to follow, that the Fire of the *Phosphorus* had an Elastick Power, which exerted itself when the Pressure of the Air was lessened.

IV. The said Water being afterwards cold, and having stood about an Hour in the open Air, it was observed, that whilst it was unmoved it yielded no Light at all, nor could any Part of it be seen in the Dark, but being shaken, it fired (as we speak upon this occasion) or flashed after the manner as Sea-Water does in Summer : And we found also about a Week after, that the said Water, upon shaking the Glass in the Dark ; did still give Light like the Water of our Ditches in a hot Summer, notwithstanding that the Glass remained always unstop'd and open. Yea, it may be inferr'd from hence, that Fire does likewise cleave to Water. And if the firing of the Sea, and some of our Inland Salt-Waters proceeds from this Cause, that such a Substance cleaves or joins itself to them, one may likewise conclude from thence, that (how strange soever it may appear) Fire does also mingle itself with Water in a great Quantity, without being extinguished by it, if there be but the least degree of Warmth therein.

V. I must add hereto, that this *Phosphorus*, with which all these Experiments were made, had lain at that time four or five Years under Water, and had been kept in the same ; so that even Water being cold, seems to be capable of serving for a proper place to keep Fire in, and from whence the same Fire remaining unextinguished, may upon all occasions be produced.

VI. Now, whether we may from hence form an Hypothesis, that this ignite Matter owes its Birth either to the Air, or to the Rays of the Sun that are therein, since the Urine of Animals can produce no such *Phosphorus*, without having been a long time exposed to the open Air and Light of the Sun, and likewise thoroughly fermented and putrified ; as also, whether the Cause why this Fire cleaves to the fermenting Urine, be on account of its Saltness, so far as in other Waters also, which are salt or brackish, such Fire or Flame is commonly observed, we are not yet ripe enough in Physical Knowledge to determine any thing about it here : This is certain, that when the Air and Light have acted a long time upon any such Matter, many *Phosphorus's* will proceed from thence ; and that there is a very great quantity of Fire scatter'd in the Air, which exerts itself in some manner in all Meteors, but in Lightning particularly, after a dreadful manner. Now Lightning, quite contrary to the Nature of other Fires, seems to want nothing but the Heat of the Sun to kindle it ; and accordingly it is observed to be most frequent in hot Countries, and with us in warm Weather. This likewise seems to be one of the particular Properties of the Fire which is found in the *Phosphorus*, that an almost common Warmth, yea, such a one as is hardly able to kindle a Fire, or Gun-powder, will yet set the same a burning ; and when it burns, we see that like Lightning it breaks out sometimes

small luminous Particles preserved their Light till the Glass was almost exhausted

times with several Repetitions of new Flames, as I find in my Notes, that when I held a *Phosphorus* in a little Bottle exactly over a burning Candle.

I don't know whether others can shew such a Fire, even also a Liquid Matter, that can be presently set on burning so easily as this *Phosphorus* only by the Heat of one of our Summer Days; but I never saw any kind thereof, besides this ignite Matter, that appeared to me in its manner of Inflammation so analogous to that of Lightning: For as for all other ways that are made use of by the Philosophers, to shew how Lightning is kindled in the Air, there seems to be either a real burning Fire, or some other Matters supposed, which many will not allow to have place in the Air.

SECT. XXVI. *A Fluid Phosphorus.*

WE find this *Phosphorus* useful for discovering Properties of Fire in many other Cases; and among others, it seems to serve for a Proof and Confirmation of what has been said above, §. VI, &c. namely, that Fire is a particular fluid Matter: Forasmuch as this compressed Fire in the *Phosphorus* will suffer itself to be dissolved in Oil of Cloves, and some other Oils, and communicate to the same some ignite Particles; so that if you let a little piece thereof lie any time in the said Oil, it will acquire a Faculty of shining, and represent a liquid *Phosphorus*: At the same time however, refusing to be dissolved, and to mix itself with many other Oils and Liquors. This likewise does in some manner seem to shew that Fire, at least that which is in the *Phosphorus*, does consist of a particular determinate Matter.

SECT. XXVII. *Preparation of the Phosphorus.*

I WAS not here minded to describe Chymical Processes in all their Circumstances; but to the End that every one may be assured of the Truth of what we have here said, and have an Opportunity of enquiring farther into the Properties of Fire by the means of this ignite Matter, I shall here add a Method of making the same more convenient than those which many Chymists have left behind in their Writings, because it does not stand in need of the so troublesome way of evaporating the Urine. That which I find in my Chymical Observations about it, is as follows:

I took the Dregs or Settlings of Urine, that had stood a long time in a Tub in an Hospital, and had thereby acquired the Thickness of Soap; I put some Rain-Water to it, stirring it about, in order to incorporate them together as much as was possible, and by pouring off the uppermost and thinnest Parts of it, I separated the other Impurities from it. Then I let it stand in the said Water so long, till the Matter that was in it did all entirely subside; from which afterwards, by the Repetition of fresh Water, all the Salts were separated. This the Chymists call *Edulcorating*, that is to say, making sweet or fresh. This subsided Matter being dried in a hot Iron Pot, was put into two little Retorts, and placed after such a manner in the smallest Reverberating Furnace, that that which we had a mind should come over by Distillation, might

might not rise too high. Then next Morning, at half an hour after Six, I put Fire under it, but joined no Recipient to it; and about half an hour after Eight, a yellowish Matter began to come over, which dropt into two little Glasses set under it, and would make an Ebullition with Aquafortis. At One a Clock of the same Day, when the Fume and yellow Drops ceased to come out of the Retorts, there were two little Vessels, the Mouths of which were prepared before for that Purpose, fasten'd on with Luting; being first fill'd with Water in such a manner, that the Orifices of the Retorts might be just above the Water; and we presently observed something like Lightning in the said Vessels. At Three a Clock the Air which was in those Vessels over the Water, was glowing and red, and Phosphorus lay at the Bottom of the said Water. The Furnace itself was made narrower than it should be for other Occasions, but the Fire-place had its entire Magnitude, to the end, that it might afford as strong a Heat as possible; and to prevent the Diminution of it by the frequent Addition of fresh Turf, it continually was supplied at last with those burnt ones that are used to be kept in the extinguishing Pots.

SECT. XXVII. *Convictions from the foregoing Observations.*

BUT to return to the Business: Since we see in this Phosphorus such a Fire, which upon the Accession of any Warmth, cannot only not be extinguished by Water, but may be kindled and burn therein; since likewise we see something of the same Nature to happen in Lightning, which, altho' surrounded by so many thick watry Clouds, yet is not hinder'd from being kindled in the midst of 'em, and from setting on Fire every thing about it: Since we see farther, that this Fire of the Air mingles itself with Salt-Waters, and in the Summer-time, causes them to flash and shine; and besides, makes Gun-powder and Salt-petre, when set on Fire, to burn in Water just as they would do out of it: To say nothing of the subterraneous Fires, that rage so terribly, tho' they lye under the deepest Sea: I say, if an Atheist would consider all these things, is it possible for him to acquiesce in so poor an Evasion as this, that the Water when once it is put into a general Operation, can secure him either from the Etherial or Subterraneous Fires.



CONTEMPLATION XXII.

Of Beasts, Fowls, and Fishes.

SECT. I. *Transition to the Beasts.*

HAVING already contemplated Mankind under so many Circumstances, namely, with respect to the Air in which we breathe; with respect to Water that serves us for Drink; with respect to the Earth that yields us both Food and Dwelling; and lastly, with respect to Fire, whereby such great things are brought about, it hardly seems credible, that any one can reflect upon all the foregoing Particulars with due Attention, without being convinced of the Existence of a Wise, Powerful and Gracious God. And in Case all this be not sufficient to disengage him from his deplorable Scepticism, let him proceed farther on with us, and silently and seriously contemplate the Beasts that inhabit the Earth, the Birds of the Air, and the Fishes of the Waters, and perhaps the Creator of all those Beings may vouchsafe to bring the Proof of his adorable Perfections, that shine forth therein, powerfully home to his Heart and Understanding.

We have already treated concerning Men, and the wonderful Structure of their Bodies (which otherwise ought to have had the first Rank here;) for which reason we shall not enter farther into that Matter now; we shall likewise pass by every thing in Beasts that have any Analogy or Likeness with Men, such as the Structure of their Bowels, Muscles, Circulation of the Blood, &c. So that after one or two General Remarks, we shall only here propose some Particulars of Birds, Fishes, and other kinds of Animals; leaving the farther Enquiry, wherewith many large Volumes have been filled, to the Study of those that examine them with a design of Learning, to know God from thence.

SECT. II, and III. *Concerning Tame and Wild Beasts; and the Text in Genesis, Ch. ix. v. 2. relating to the same.*

To come then properly to the Matter; we are wont to distinguish the Beasts into Tame and Wild: Can then any Body imagine, that he is able to prove, that it is owing to Chance, or to any Causes necessarily resulting from the Structure of Animals, that the Tame Beasts, which are so useful and serviceable to Mankind, either for Cloathing or Feeding them, or for other Purposes, such as Kine, Sheep, Horses, and the rest, seem disposed by Nature to be Domestick Animals, and to live among us: Whereas the Wild, such as Lyons, Bears, Tygers, Wolves, Serpents, and the like, delight to dwell in

Woods

Woods and Solitary Desarts, and of their own accord seem to avoid the Company of Men? Now if this were quite the Reverse, and the devouring and poisonous Creatures should keep together in Flocks, and exert their Violence against Mankind, how much Pains and Trouble would it require in many places to defend our selves against their Assaults.

We ought therefore to consider with no less Amazement than Attention, that Text in *Genesis*, Ch. ix. v. 2. ; where GOD says to Noah and his Sons, *The fear of you and the dread of you shall be upon every Beast of the Earth, and upon every Fowl of the Air, upon all that moveth upon the Earth, and upon all the Fishes of the Sea; into your hand are they delivered.* And to observe how many Thousands of Years this Word has continued true. Could a Man that had seen an Elephant, a Bull, or a wild Horse provok'd, enraged, and then let out to do what Mischief he would (and who did not know after what manner People used to Tame these furious Animals, and many others, and render them serviceable) ever believe the same without looking upon the above-quoted Text as a wonderful Prophecy? And not to mention Birds and Fishes (without even excepting the greatest Whales) in which the same is very plain and manifest, it is well known, from a multitude of Examples, that this has place in the most devouring and pernicious Creatures: For not to repeat what we have already said, that of their own Nature they chuse to live in Wildernesses and uninhabited Countries, we may meet with a very remarkable Evidence thereof in the *Ephemer. German.* 9th and 10th Years, p. 453; namely, that a Lyon will never assault a Man, unless compell'd thereto by Hunger, Self-defence, or the Discharge of a Gun against him; and in relation to Tygers we read the following Passage; *they are afraid of white and naked Men, like* (which is very remarkable) *all wild Beasts of Asia and Africa, and avoid them as it were a kind of Reverence; and it is without example that they attacked any such.* After having understood all this, let an Infidel himself tell us, whether Moses, whom he must account a great Politician, would not have acted against common Prudence, when he pretended that those Words which at that time when they were spoken, were so little probable, proceeded from GOD, whom he served, and whom he desired that *Israel* should likewise serve.

SECT. IV. *The Structure of Beasts in general, and Convictions from thence.*

TO come now to some Particulars: If we should contemplate all Beasts, Great and Small, Wild and Tame, and at the same time suppose that there was but one of each Kind in the World: Then, should any one view with a Microscope the Structure of the least, even of the most contemptible Fly, or smallest Mite in a Cheese; could he forbear acknowledging each of them to be a Miracle of Nature; and not be sufficiently convinced, that He who had formed all the Members of them, so useful, with respect to each other, must have been very wise; and that in providing them with a Mouth, Feet, and other Parts, he did it with a Design that they should eat and walk, and discharge other necessary Functions therewith!

It is wonderful again, that these unhappy Philosophers, seeing an artificial Mouſe or Fly, by the help of Springs and Wheels, like a Watch, enabled to perform ſome of the moſt common and rudeſt Motions of thoſe Creatures, think they can never ſufficiently commend the Skill and Contrivance of the Maker : And yet when we ſee the Original, the living Creatures themſelves, in which they are forced to confeſs there is infinitely more Skill and Judgment to be found, do yet maintain, that He that formed them, was endowed neither with Wiſdom nor Underſtanding.

SECT. V. Of Procreation in general.

BUT now ſuppoſe one ſhould ſhew them of each Species of Beaſts, not one only, as above, but two, Male and Female, both endowed with Parts of Generation relative to each other, and enabled thereby to propagate their Kind : Let the moſt preſumptuous and conceited Atheiſt, though never ſo well verſed in Mathematics or Mechanics, propoſe to himſelf the following Problem, namely, *To make two Animals of the ſame Species, which beſides all other Faculties of Eating, Drinking, Running, Flying, and the like, have likewiſe that wonderful Property of jointly producing other Creatures of their own Kind, and ſo to continue their Poſterity after their own Kind.* And let him answer us, whether he could be able to do this with all his Wiſdom ; and if not, whether he muſt not eſteem him that can do it, as much wiſer than himſelf, and all other Men together.

This being done, let him with us contemplate not one, nor two, but thouſands of ſuch Creatures in the World ; and then conſider with himſelf, whether a pious Enquirer is ſo much in the wrong, when he acknowledges the adorable Glory of the Great Creator in all theſe things ; who, to the end that every reaſonable Being that ſees theſe his Wonders, even in ſuch ſmall Creatures, may be thereby convinced of his Power, of his Wiſdom, and of his Bountifulneſs, which He extends to the moſt contemptible Animals.

If this be not true, how comes it to paſs that in each of the two Sexes, reſpective Parts for Procreation are ſo accurately adapted, that among ſo many Millions, there is hardly one only to be found, that is not or will not be rightly form'd for propagating his Kind. And if this were not the Deſign and Purpoſe of the Creator, what Reaſon can be alledged, that all kind of Creatures living, both upon the Earth, in the Air and Water (how different ſoever in Nature, Figure and Size, they may be) are hurried with ſo ſtrong an Inclination, yea even with Rage and Madneſs, to propagate their Species ? Inſomuch, that one cannot contemplate the ſame without Terror many times in thoſe Creatures that are ſtrong enough to do miſchief.

SECT. VI. Generation performed after various Manners.

THE rather (whereby all Eviſions are cut off) ſince the wiſe Creator of all things living has cauſed this Propagation of the Species to be performed after ſo many and various Ways, that whoever is endowed with any Reaſon or Equity, muſt be convinced, that all this proves in the cleareſt manner,

manner, the Work of a free and wise Divine Pleasure, but by no means of a natural Necessity, operating always after the same manner.

Thus we see, that Men, Kine, Sheep, and numberless other Creatures, are received and formed in their Mothers Body.

That most Birds are indeed received in their Mothers Body, but are formed in an Egg out of the same.

That many Fishes (as the Experience of Fishers and other Enquirers inform us) are not only shaped, but likewise received out of their Mothers Body; forasmuch as the Female or Spawn-Fishes, discharging their Spawn in convenient Places in the Water, the Males resort thither, and impregnate the same; whereby the little Eggs in the Spawn are fecundated, and Fishes of the same Kind are produced from thence.

The First is performed entirely in an Animal and Liquid Warmth.

The Second, so far as it relates to the Reception, is after the same manner; but the Formation is in a dry and different Warmth: So that in some Countries many Chickens are hatched from Eggs, in Ovens made expressly for that Purpose; not to take notice that Women likewise have hatched Chickens from Eggs by the Warmth of their Bosoms.

The Third, concerning Fishes, happens both ways in Cold Water, without any remarkable Warmth.

And besides this, to shew that the Great Ruler of all things will not suffer himself to be bound by any Necessity or Fatality, we may see other Fishes to be conceived likewise in their Mothers Body, such as *Carps*, the Spawn-ing-time of which is well known to the Fishers, that testifie the same. But besides these, there are other Fishes likewise formed in their Mothers Body, such as *Whales*, in which People have oftentimes found living Young ones of the same Species.

SECT. VII. *Animals of both Sexes.*

BUT farther to prove this last, and the unlimited Will of the Great Creator of all things in the Execution of his own wise Purposes, could it be believed that there is a Species of Creatures, which are at the same time both Male and Female, and which do copulate with each other after both ways? They that desire to be satisfied therein, may consult the *History of the French Academy* for the Year 1699. p. 46, 47, &c. where Mr. *Poupart* affirms, that he had observed it in Worms that are in the Earth, which would get into a proper Hole for that purpose by two and two, after such Manner that they can stretch themselves strait out by each other, placing the Head of one by the Tail of the other; after which manner they Copulate, and have been so found in Spring in warm and moist Weather. This has caused Mr. *Homberg* to doubt, whether this Kind of Worms might not impregnate themselves, since they can conveniently bend their Bodies, and become Males at one end, and Females at the other, into which we shall not farther enquire. Mr. *Poupart* does likewise give us there a rough Enumeration of the Creatures, in which he says, he is sure that this Particular has Place; and besides these Earth-Worms, there is mention made of another kind,

with

with round Tails, which are found in the Intestines of Men; so likewise such as are found in Horses; the Snails of the Earth, and of Fresh Waters, together with many other Kinds, and all Leeches and Blood-Suckers.

This Observation is likewise confirmed in the said History, for the Year 1708, with many Circumstances about Snails, by Mr. du Verney, as also by Dr. Lister, in his *Anatomical Exercitations*, as they are mention'd in the *Aët. Lips.* 1695. p. 318; and Mr. Blancart, in the *Theatre of Rupsen*, relates the Observations of Swammerdam, concerning the Coition of the Horn-Snails, who have in their Neck both the Parts of Generation by each other, and are wont to brandish the Male *Virga* several times, till it can meet with the Female Part of the other on both sides the *Tab. XVI. Fig. 4.* will shew this without farther Explanation.

SECT. VIII. *Convictions from the foregoing Observations.*

I HOPE there will be no occasion here of using many Arguments to convince a Sceptick, that one who acknowledges a GOD, will not maintain so absurdly, when he sees that one and the same End of Generation is performed after so many different ways (each of which is the result of wonderful Wisdom) that this whole Work is to be ascribed to meer Chance, by reason of the Skill and Contrivance appearing therein; Nor yet to a blind and ignorant necessary Cause, on account of the Diversity and Variety whereby the same End is so wisely pursued: But much rather attribute it entirely to GOD, who being neither limited by Laws, by Methods, nor by Instruments, in revealing his Wonders to Mankind, does make every thing according to his own good Pleasure, and the Council of his Will.

SECT. IX. *Young ones produced upon the back of a Pipal.*

NOW, after how many different Manners, besides those already mention'd, the Production of Living Creatures into the World is performed, may be seen in those Treatises that have expressly handled this Matter: And that we may be once again convinced, that this is only to be ascribed to a Supreme Will, directing all things according to its determinate Purposes, and which is bound by no particular Rules, we may contemplate the Production of *Caterpillars*, *Silk-Worms*, and the like, and observe how much they differ therein from other Creatures, being not fit for it before that they are entirely and specifically changed, and from creeping become flying Creatures.

Besides all this, the Belly of the Female Animals seems to be the principally designed Part for the Procreation of their Young; but again, because none should imagine that this were an absolute Necessity, and to be ascribed only to the unknown Laws of Nature, let him consult the Second and Third Figure in the Fourth Table of the *First Cabinet of Animals*, of Mr. Ruych, where, to his great Astonishment, without doubt he will find an *American* Animal, called the *Pipal*, like a Toad, which produces its Young ones out of its Back; so that neither those Creatures, nor the Eggs from whence they come, have any Communication with the Cavity of the Belly.

SECT. X. *The Food of Animals.*

AND to the end, that it may not be thought that the Generation of Animals is not just the only thing in which the Wisdom of the Maker shines out equally with his Free Will and Pleasure; by which he does all things to his own Glory, and to the Confusion of those who represent his unbounded Power by the Likeness of a Clock, or other Artificial Machine, that Works necessarily and ignorantly; Let the Atheist contemplate those Parts of Animals that are useful to them in Feeding; and let him observe particularly how Kine, and other Beasts that have no Teeth above, and upon that account can't chew their Meat small enough at once, are provided with a Maw, in which the Grass they swallow is thoroughly moisten'd, to the end, that when it is brought up again into the Mouth, being Softer and Mellow, it may be render'd as small as is necessary by a second Mastication, which is called chewing the Cud; and how, after having been swallowed the second Time, it descends into other Ventracles or Bowels, where it is first turned to a proper Chyle, in order to nourish them; concerning which those who have expressly written may be consulted. Thus also there are some other Animals fed with Grass, that do not serve for Food to others. In the Dutchy of *Crain* in *Austria*, there are found black Snails as big as ones Fift, and not inferior in tast to Oysters, living in the midst of a very hard Rock, which must be broke in pieces to come at them. Let any one guess how, and with what these Creatures are nourished. But I only ask this Question, *first*, Whether it can be supposed to happen by Chance, or without Wisdom, that these Cud-chewing Animals, which are deprived of an upper Row of Teeth, are furnished with such a particular Manner of Digestion, and that Dogs, Swine, and all kind of Fowl that do not want it, are not provided with the same. And, *Secondly*, Whether it does not fully appear from thence, that He who has given to all Animals the proper Instruments for Feeding, is not bound by any necessary Laws of Nature, which tending all to the same Purpose, do always act after the same Manner.

SECT. XI. *The Motion of Animals in General.*

THE same does likewise appear from the Diversity of Motions in Animals, whereby they pass from one place to another. Thus most Birds both small and great, have Feet for Running, and Wings for Flying; Fishes have no Feet, but Tails and Finns for Swimming; some Beasts have two, some four, others more Feet for Running; others having neither Feet nor Wings, do creep; others, as some Shell-Fish, draw themselves along by Threads, making use of a quite different manner in moving from one place to another. See concerning the same, the *Memoirs of the French Academy*, 1706. p. 69. Now in all this we may observe different Methods serving the same End, and each of 'em executing the wise Purposes of the Creator, being adapted thereto after a particular and wonderful Manner.

TAB. XVI

Fig. 2.

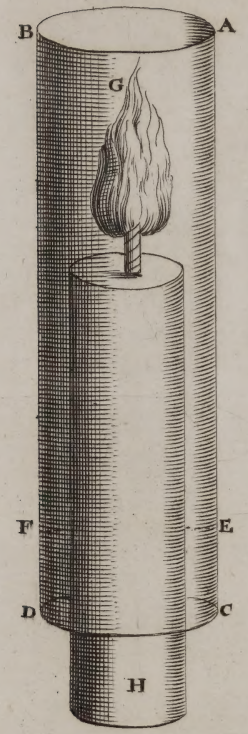


Fig. 1.

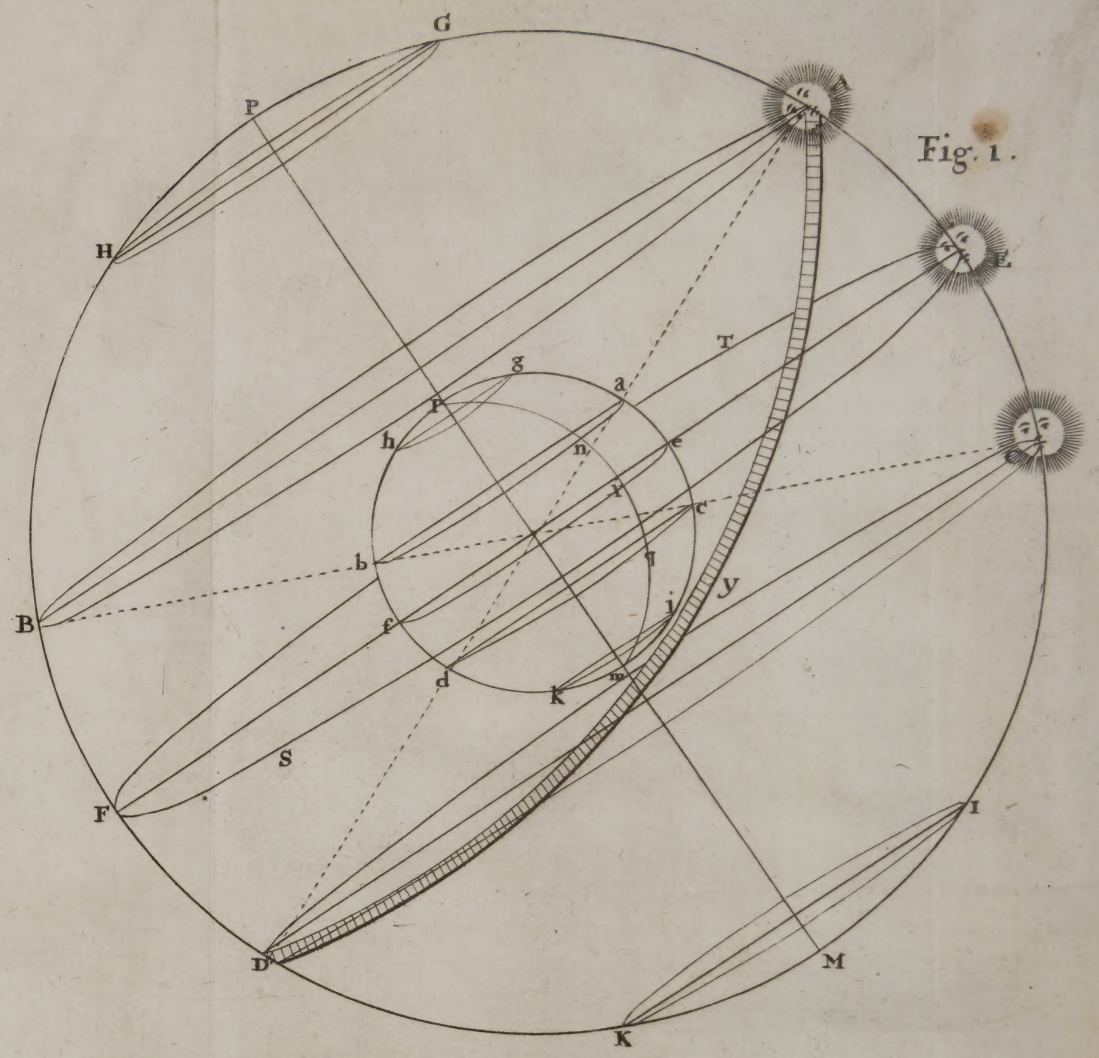


Fig. 4.

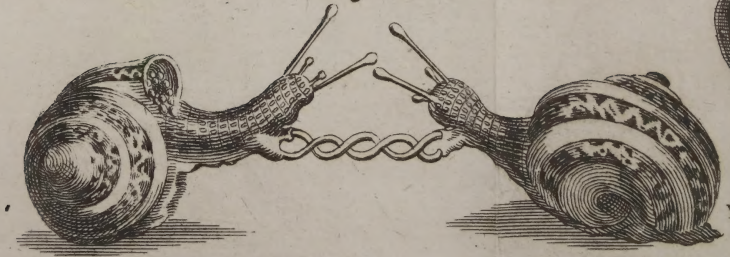
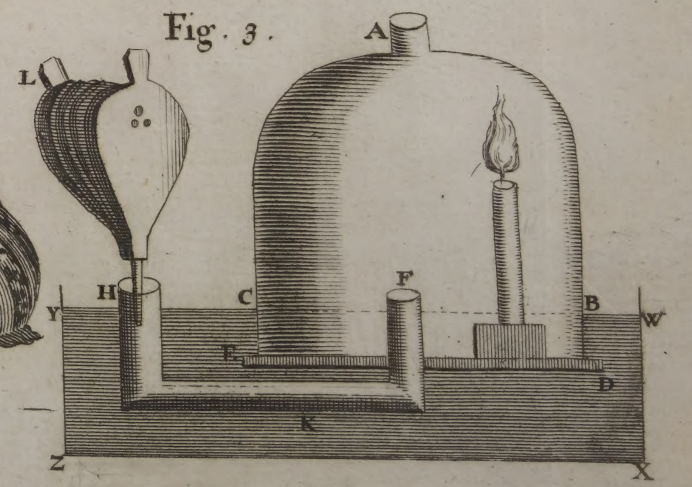


Fig. 3.



SECT. XII. *The Structure of Birds.*

AND not to stop at those Particulars which seem to have some Analogy with those of the Humane Kind, forasmuch as we have treated of them in another place ; let the unhappy Atheist contemplate the Birds, and let him ask himself, whether (in order to deny, with some appearance of Reason, the Wisdom and Power of an adorable GOD) he can be contented necessarily to conclude, that all those Instruments which are requisite for Going, Flying, Eating and Procreating, so necessarily and so artfully adapted to all these Purposes, are owing to mere Chance, and to the ignorant and necessary Laws of Nature : And whether he can conceive, that without an over-ruling Power and Providence, a Bird so wisely form'd for Flying, not to speak of other Faculties, can have acquired its Existence out of that Matter and Substance with which an Egg is filled, only by a brooding Heat ?

SECT. XIII. *The hollow Tubes or Bones of a Bird.*

LET him first contemplate the little Bones of a Bird, and he'll find those of their Legs to be much hollower, as well as the Substance of them much thinner, than those of other Creatures ; the reason of which is, that the Bird may be lighter, and so more fit for Flying. But to the end, that the thinness of the Bone should not render it weaker, it seems necessary that the Substance of it shou'd be harder and stronger than in those of other Animals. Now if we consult the Observations of those that have inquired into it, we shall find it to be so in Fact. Will then our unhappily blind Philosopher maintain, that this also comes to pass without Wisdom and Design ?

SECT. XIV. *The Cartilages in the Joints, and Convictions from thence.*

MOREOVER, let any one who has, for Instance, a Pullet upon his Table, examine the same, and see how in that, as in other Animals (of which something has been said before in *Contemplation* XI. §. VIII.) the end of these little Legs are encompassed with a smooth or polished Cartilage, to move and bend the same conveniently, some are moved by means of a round Cavity, which is likewise clad with a Cartilage, and others by means of two circular Protuberances in two like Cavities adapted thereto : Let him afterwards attentively view the little Joints in the Claws of such a Pullet, and he will find, that here likewise, as well as in the great Bones of the largest Ox, the Extremities of these so small Bones are encompass'd with smooth Cartilages, to the end, that in the Motion of them, one Bone may slide upon the other more easily, and the proper Motions be performed in every Part without any Obstruction.

Now if there be not a wise Contrivance in this whole Structure, why are not all the Bones (which would then be too weak) composed of mere Cartilages only ? Why do they occur in those Parts alone, where by their Smoothness they render the Motion more Light and Serviceable ? Why is

one End of the Leg spherical, or exactly round, where it is necessary to be moved not only forwards and backwards, but also sidewise? And at the other end, where there is no occasion for such lateral Motion, there are two such Protuberances formed, as to hinder it from being inflected otherwise than backwards or forwards? He who sees all these things, and so many others, which can only serve for their particular Uses, and shall judge, that they have acquired such a Disposition without Wisdom and Design; why may he not as well, in reading a Book or a News-Paper, affirm, that all the Letters are ranged in the Form he finds them in, by mere Chance likewise, and without any Design of the Printer?

SECT. XV. *How the Wings are moved in Flying.*

BUT now if we carefully observe, first, after what manner the Birds fly, and make use of their Wings for that Purpose; and next, how these Wings are made and put together; so that no Man living could have contrived 'em so artificially, and prepared 'em for Service; I am not without Hope, that this may convince, if not all, yet at least some Sceptical Minds, and oblige 'em to confess, that Wings are as much given to Birds for the End of Flying, as the Hand of a Watch is made for shewing the Hours.

To be satisfied of it, let us remark, that a Bird moving its Wings, does not strike them from the Fore Part backwards, nor use them like Oars, after which manner they would very much obstruct the Action of Flying; since being brought forwards with so much swiftness, they would strike against the Air, and so either drive the Bird backwards, or at least hinder its proceeding forwards: Forasmuch as their Structure is quite different from that of the Claws of Geese, Swans and Ducks, &c. which, because it hath pleased the Creator, that these Kinds of Fowls should make use of the same, as of the Oars of a Boat, their Wings are of an entirely different Structure, of which hereafter. And in case any Progress could be made by the Birds through the Air after this manner, yet the Bird itself by being heavier than so much Air, would fall down, or at least sink leisurely downwards. But not to dwell too long upon Arguments only, we need only observe for a Proof of what has been said, that great Birds, such as Ostriches, Storks and Swans (in which, by reason of the slow Motion of their Wings, the same may be clearly seen) in Flying, strike their Wings up and down, (or perpendicularly to the Horizon, as Mathematicians term it) whereby we find, that the Bird is at the same time supported and moves forwards in the Air.

Can we then perceive no Wisdom herein! That these Wings (*Tab. XVII. Fig. 1.*) A E and B F, of the flying Fowl B G A, are somewhat hollow below, in order to take hold of the Air with so much more Force and Power in striking them down; and above they are Convex, that in lifting 'em up they may meet with the less Resistance from the Air; and so that they mayn't lose in the raising of their Wings that which they gain'd in striking them down, to keep them floating in the Air. But that which is here particularly to be observed, is, that these Wings are not fasten'd to the Body by their whole

whole Breadth, but only at A and B, all the other Parts thereof being intirely loose ; whereby it happens, that (as may be seen in the Observations of *Borelli*, *Prop.* CLXXXIII, and CLXXXIV.) the said Wings being raised up, do only cut the Air upwards with the sharp Fore part A E and B F, that they may meet with less Resistance ; but striking the Air downwards with a greater Swiftness, they describe with all their Points, Lines that are almost circular, such as E I P and F V L.

But since the wonderful Manner whereby a Bird cuts the Air with his Wings upwards and downwards, and moves them forwards at the same time with so great a Velocity, cannot so easily be described nor comprehended by Words ; let us represent to our selves in *Tab.* XVII. *Fig.* 2. a Bird R S, as he floats in the Air, and extends both his Wings B E A and B C F ; we may then suppose, that when these Wings are moved directly downwards, the Arms thereof, B C and B E, which being composed of Bone, and therefore stiff and hard enough to describe two Circles whose Planes make Right Angles with the Horizon, as in the foregoing *Fig.* 1. *Tab.* XVII. and so cause the whole Wing to follow that Motion, and to exert its Force with this perpendicular Blow upon the Air that lies under it, H G B E A.

Now, forasmuch as this Air, when struck by the Concave Superficies of the said Wing, makes a Resistance (as it happens when Women move their Fans through the Air) because it cannot recede quick enough : And moreover, as the Parts of the Air being compressed by the Velocity of the Blow, do sensibly endeavour to expand again, as we have sufficiently proved above in *Contemplation* XVII. about the Elasticity of the Air ; and as appears plain enough from the rushing Noise which Birds make by flying or stirring their Wings ; it will follow, that the Feathers E A O, by the said Resistance and Elasticity of the Air, will bend upwards, being made of a flexible Matter ; and therefore when the Arms B E and B C, composed of an inflexible Bone, pursue their way in striking downwards, the Ends of their Wings, A and E, will, by the bending of the Feathers upwards, be pressed towards each other.

From hence it is easie to see, that the Air being beaten downwards by the Wings, and by its Elasticity resisting upwards, the Bird is supported in it by the repeated Reverberation at every Blow. And forasmuch as by the Flexion upwards and downwards of the Feathers of the Wing, the Air receives the Blow obliquely in the Motion thereof, we may from thence give the reason why the Bird is thereby pushed forwards, and horizontally towards R, and so is said to perform the Action of Flying. So that the Beginning of the perpendicular striking upon the Air, does chiefly support the Bird, and the Continuation of the said Blow does chiefly promote the Bird's progressive Motion.

Perhaps this may be render'd more intelligible to some, by supposing, as *Borelli* does, the Bird, R S, to be at rest, and without Motion, and that it holds its Wings, B E A and C F, horizontal ; and that by a Wind, H G O, blowing directly upwards against the said Wings, their Ends A and D being bent

bent towards each other upon the Back of the Bird, the two Wings do thereby represent the Figure of a Wedge running obliquely into the Points A F. Now if both the Sides of this Wedge are pressed by the opening Air or Wind, every one knows that it must follow from thence, that it will be protruded towards its broadest Part C B E, and so carry with it the Bird R S, which is fasten'd to it at O. Now those that understand Mechanick, know well enough, that the same Effect will be produced, whether the Air be moved upwards as a Wind, or the Wing downwards.

I wish I could here substitute any known Machine proper to shew the true manner of the Action of the Wings, and to give a greater Light to the Unexperienced, how the exactly circular striking down of the Arms or Bones that are in the Wings joined to the Flexion of the Feathers upwards, can at the same time support a Bird in the Air, and cause him to fly forwards. But I must own I know of none my self, nor find any such in others.

Something like it, tho' very imperfect, occurs in the Sails of our Wind-Mills, as also in Ships that sail with a side or half Wind; which however only shews how the Wind blowing from one Point causes the Sails of a Mill or a Ship to move forwards towards one another: This happens in some manner likewise to the Wings of a Bird when it flies, but does however by no means represent the true Manner of Flying.

Yet to suggest something that has a little more Analogy with the Motion of the Wings; let half a Sheet of Paper be fasten'd to a little Stick in the same manner as the Colours are fasten'd to an Ensign-Staff; the said Stick is to represent an Arm or Bone of the Wing, and the flat Paper the Feathers, which must not hang down under the Stick, but be held up in the Air by it. Now if you move this Stick with your Hand in a direct circular Motion from above to below, and the same be done pretty swiftly; you will see, that the Paper is thereby moved, first from beneath, upwards, and next from backwards, forwards; from whence one may form a rough Conception (since the same thing happens in each of the Wings on both sides of the Bird, by the striking down of the Arm) how the Bird moves upwards and forwards at the same time; in which Flying consists.

SECT. XVI. *The Wonderful Structure of the Wings.*

Now whoever has attentively consider'd what has been said, and understands what we have here said about the Action of Flying, will see, that in order to make a Bird fly, the Feather of his Wings must necessarily be, *First*, Light, that they may not obstruct nor incumber him; *Secondly*, Flexible; and *Thirdly*, Stiff and Elastical, that is, that being bent, they may resume their natural State, by springing back of themselves.

Now let us Contemplate the same, just as we observe them in Birds, and we shall find;

I. That the Quills to which the Feathers are fasten'd are hollow, that they may be light, and nevertheless stiff and hard, as being composed of a thin and horny Substance.

II. The

II. The remaining or lower Part of the Quill must not be inflexible, because in striking down of the Wing, it was necessary that it should be capable of Inflection by the Resistance of the Air, to the end, as we have said before, that the two Wings might approach each other, in order to meet the Air obliquely, and protrude the Bird forwards. Now we find that this part of the Quill is filled with a Matter that is very flexible and light, and which seems to me to be found no where else but there, as indeed it is there only necessary, for it does not seem reducible either to Bone, Flesh, Membrane or Tendon, or indeed to any kind of Parts that occur in these or other Animals. Now can any one pretend, that this is also to be ascribed to Chance, or Ignorant Causes?

III. Now it is not enough that these Quills should be flexible, for so is a Rope too; but it is moreover requisite, that in the perpendicular Motion of the Wings, they should be stiff and hard enough too, to act with some Force upon the Air, and that being bent upwards by such Acting, they may in the lifting up of the Wing resume their former and concave Figure.

Now all this concurs in the Structure of the Quill; for in the external Circular Part thereof it is cover'd with a Bark, which is in some measure hard, and under that, in the Cavity of it, there run two long protuberant Lines of the same Matter, parallel with each other (as is visible in a Writing-Pen) covering and encompassing the aforesaid wonderful Matter, like Marrow in Bones: Now that they become hereby stiff, flexible and elastical, will be obvious enough, by bending them a little, and then letting 'em go suddenly again.

IV. But to the end that the Air may not soak thro' these Quills, and so render the Force of the Wings vain, there are lateral or cross Fibres placed in the Feather on the sides, which do not only exert each of 'em their Elastick Faculty, as fine and small as they are, but do likewise adhere together, in order to prevent any Passage of the Air. Now since this can have no Place in the Quills where there should be Pores or Orifices, we find those Interstices cover'd with little Feathers that grow continually smaller, like the Scales of Fish, lying upon each other, whereby they do sufficiently hinder any Passages of the Air between the Quills.

Now, notwithstanding all these Functions and Uses, every Feather is so disposed, that it may not obstruct the Bird in Flying, that nothing can more verifie the Proverb, *as light as a Feather*, than such a Disposition.

Now with how great Art even the smallest Fibres are formed therein, may appear from hence, that each of 'em has again the same Structure as a large Quill or Feather, and does likewise consist of a Body passing thro' the middle of 'em, and little Fibres on the Sides: To be convinced of this, we need only examine a small Particle of one of these little Feathers with a good Microscope.

SECT. XVII. *Convictions from the foregoing Observations.*

CAN any one imagine, after all this, that a single Feather (to go no farther at present) has without any End or Wisdom acquired its Structure, its

Hardness, and at the same time its Elastic Power, its peculiar Substance and Lightness, its Disposition and its Place, just in that Part of the Wing where it can be serviceable, and all other Properties necessary for the Action of Flying!

At least a Christian who has seriously consider'd the aforesaid Texture of the Feathers and the Wings which they compose, will be thereby convinced, that JEHOVAH does justly number these things among his Wonders; *Job xxxix. v. 13.* And that a Consideration of the Beauty and wonderful Structure of those Wings, is of use to represent the smallness of Man's Wisdom and Power in comparison of the Greatness of GOD's, appears from this Question; *Gavest thou the goodly Wings unto the Peacocks? or Wings and Feathers unto the Ostrich?*

SECT. XVIII. Other Reflections upon the Structure of Birds.

MANY more Remarks might be here made concerning the Structure of Birds: He that has ever seen how some little Birds that are wont to make their Nests in Thorny Hedges, are furnished with a particular Membrane, with which they can cover their Eyes, and preserve them from being pricked in their swift Passage through those Thorns; and that such Membranes are therefore transparent, like the Eye-lids of many other Creatures, to the end, that they mayn't be quite depriv'd of their Sight, will he obstinately affirm that this happens just to those Birds that want the same, without any End or Design?

If one considers the Structure of the Legs of many Birds, especially of such as are used to support themselves upon the Branches and Twigs of Trees; can it be imagined, that it is without Wisdom, *First*, that (*Tab. XVII. Fig. 3.*) a Muscle HC, runs along the Thigh-bone BC from H, the Tendon of which IK, which contracts the Claws of the Feet of the Bird, extends itself about the Angle BIK, which Angle the Thigh-bone HC makes with the next Bone CD: And to the end that they mayn't be displaced by Motion, they are carried on there thro' a Tube or Sheath, as *Borelli* affirms, §. 149. who has examined into the same in Eagles, Hawks, Swans, and other Birds? *Secondly*, That other Muscles, as KC, which are likewise useful in shutting the Claws EG, are united by their Tendons at K, with the foregoing IK, and encompass the other Angle CDE, and from thence extend themselves along DEG, in smooth Tubes, (that seem to be only made for this Purpose) to the Nails of the Claws at E and G? *Thirdly*, that when these Bones BI, ID, DE, make a right Line, the Tendons are not extended, and therefore the Claws of the Feet remain spread in the Figure of a Star? But, *Fourthly*, the Bones BCDE, forming acute Angles, and being as it were forced to lie upon each other, that then this Tendon being stretched, the Claws of the Bird are shut close thereby, and drawn together as it were like a Fist; insomuch, that *Borelli* vouches, that he could not without a great deal of Pains, thrust a sharp Stick between the closed and contracted Claws of an Eagle or a Hawk, tho' it was already Dead.

A common Experiment is usually made, by laying a dead Pullet on its back upon a Table, and stretching the Feet streight out; at which time one shall see that the Claws will be extended, and again contracted by pressing the Thighs and Legs against the Body; and then putting the Finger between the Claws, one shall easily perceive, that by such Inflection they are strongly enough closed together, to keep so fast a hold upon the Twig or Branch upon which they sleep, without the Assistance of any other Muscles, that they can abide there without any Danger of falling. And from hence likewise the Reason is plain, why this sort of Fowl, as often as they advance their Legs streight forwards, extend their Claws like Rays of a Circle, in order by the greater Breadth of them, to tread more firmly, which, without using any particular Muscles thereto, results only from the Structure of the Foot, and yet is of very great use for this Creature to walk conveniently. One may make the same Trial upon dead Sparrows and other little Birds, if one would take the trouble of examining them.

Lastly, To draw a Conclusion from the whole: Can any body think that all this Disposition in the Tendons, whereby the Claws are moved, is without any particular Design? the rather, since even the Flying Bird R S, resting itself upon the slender Branch F G, can, according to this Supposition, sleep safely, without fear of falling, tho' their Muscles should not act in Sleep as the same is proper to all Beasts; for when the Bird R S, having thrust its Head backwards upon its Body O, and thereby brought the same to an Equilibrium over its Feet, rests with the sharp Part of its Breast-Bone upon the Twig; if the Motion of the Wind, or any other Accident should put him in danger of falling, the strong Contraction of his Claws upon the same Twig, comes to his Assistance, just as if the Twig were held fast by two stiff compressed Knippers; for that such Contraction is performed with much Strength, only by the Bird's sitting down, and by bending with its Weight the Bones B C, D E, upon each other, is already demonstrated by *Borelli*, and by the aforesaid Experiments. And to any one that has but Eyes to observe the Care and Providence of GOD over all his Creatures, and even for the Birds themselves, this seems to be a particular and palpable Demonstration of his great Goodness and Wisdom, who has bestow'd upon these Animals such a Structure with respect to their Bones, Muscles and Tendons, as that without any Pains on their Part, or once waking from their Sleep, their own Weight and Figure preserves them from falling, in such Circumstances, that no body could imagine that they could remain one Minute upon the Twig at the least Motion thereof.

SECT. XIX. *The Feet of Water Fowl.*

LET no body think, that sofarasmuch as this Pinching or Contraction of the Claws, is likewise found in some Birds that live both upon Land and Water, as Swans, the same happens by Chance or by other necessary Laws, because these Birds are seldom observ'd to sit upon Trees, and therefore have little or no occasion for such a Structure of their Feet; for if it be considered that Ducks, Geese, and Swans, make use of their Feet in Swimming, as Men do

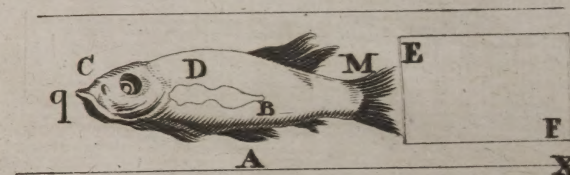
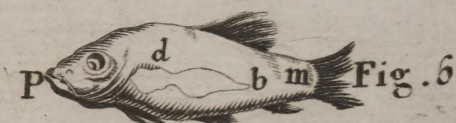
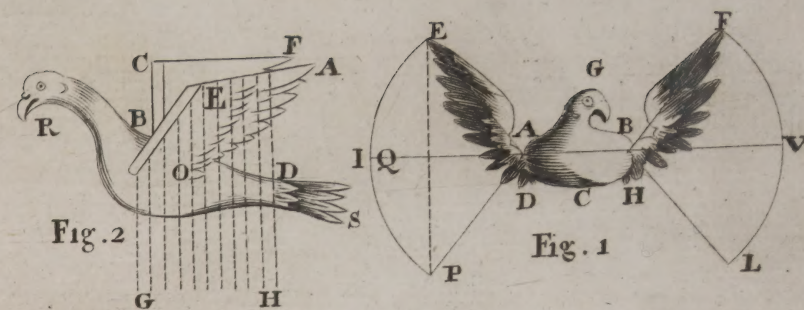
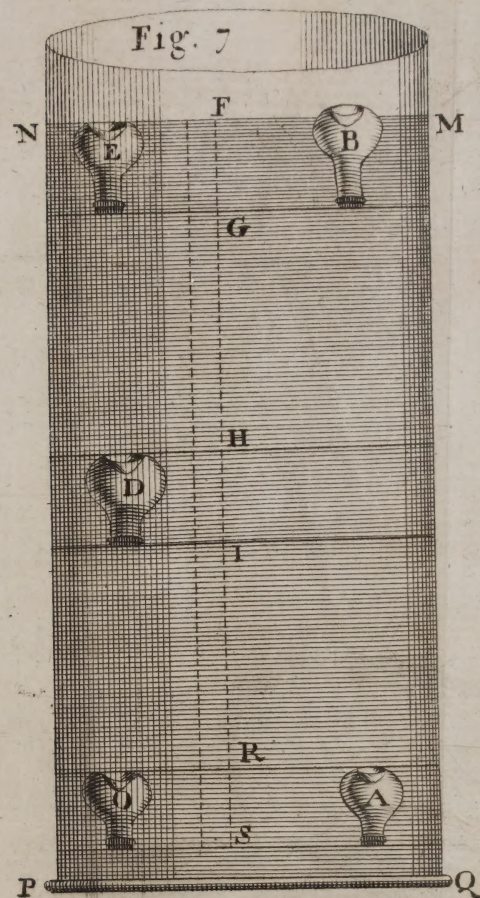
of Oars; and that their Feet are of such a Figure, that being thrust out backwards, they are expanded likewise by the Resistance of the Water, and so exert a greater Force in the Progression of the Bird; we may likewise see at the same time, that if these Feet, in their whole Breadth were to have been drawn forwards, it would have driven the Bird as much backwards; for which reason then, the Contraction of their Feet (as may be observed in Womens Fans, but after another Manner) is necessary to them, to the End that they might strike out their Feet, without giving the Water too great a hold of them: Now this happens in them likewise by those Tendons which, when they bend their Legs upwards (and so cause the Bones thereof to approach more to the others) draw their Claws together, and only by this Structure, without being obliged to make any particular Motion thereto. This Experiment may, like the former, be tried upon a dead Duck or a Teal.

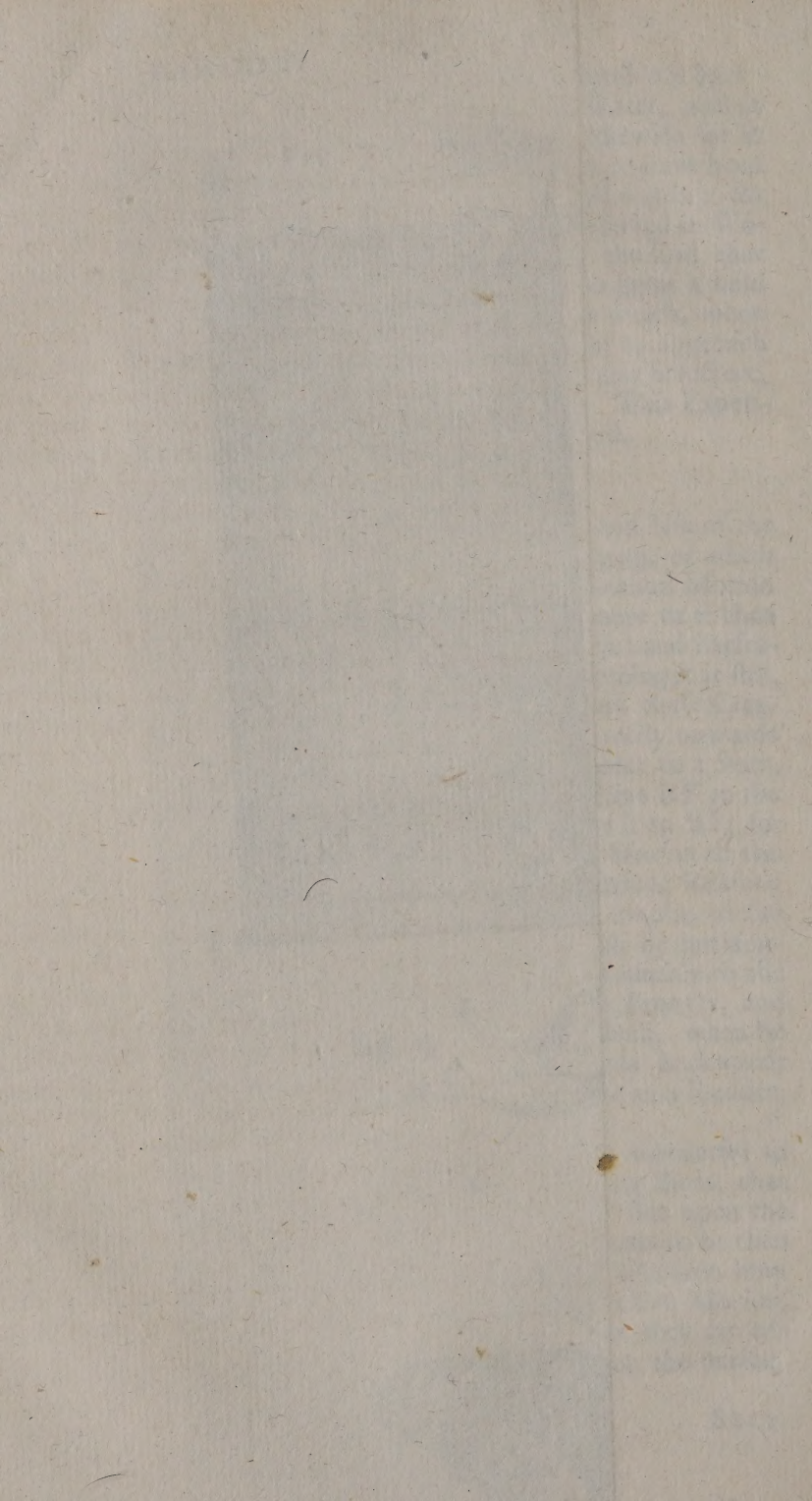
SECT. XX. *The Tails of Birds.*

BUT after having said thus much concerning the Structure and Use of the Wings, let us add a Word or two more about the Action of Flying, of which we have already said something, so far as may relate to the horizontal Motion thereof. The Structure of a Bird, if there had been nothing more in it than what they have already considered, would have been a wonderful and irrefragable Proof of the Wisdom of GOD; but how much more surprising is it still, when we contemplate another Part that he has bestowed upon these Creatures, to enable them to fly perpendicularly, that is to say, directly upwards or downwards, I mean the Tail, which is to them as the Rudder to a Ship; this the Bird raises at BH, when it moves upwards from the Line BF to the Line KL; and when downwards, in the Line NO, it lowers it to BI; for that it does not serve, or at least not commonly, in a lateral Motion to the Right or Left, is plain, from the Structure thereof. The farther Reasons may be seen in *Borelli*, Prop. CXCVIII, and CXCIX; who teaches us (as does also Observation and Experience) that when Birds which fly horizontally, without rising or falling, have a mind to turn themselves nimbly to the Right or Left, they move the Wing of the opposite Side more strongly, and after an uncommon Manner, as a Man uses his Arm and Hand, when he would turn himself in Swimming; tho' such Birds as thrust out backwards long and slender Legs in Flying, do seem likewise to use the same as a Rudder, when they turn to the one side or the other.

There still remains something which does as it were appear wonderful to those that consider it; namely, how it is possible that swift flying Birds, that descend perpendicularly from any great Height, do not fall flat upon the Ground at once, the rather, since the Swiftness of their Fall seems to be then increased by the Weight of their Bodies: Now they that have ever seen how artfully they use their Wings, to moderate and stop their progressive Motion, and how they spread their Tails, must at least acknowledge that they are admirably provided with every thing necessary for Flying, and for the various Uses of their Wings and Tails.

TAB. XVII





SECT. XXI. *The Center of Gravity, and Force of the Muscles of the Wings.*

NOW after all that has been said, I shall not dwell upon that wonderful Structure which Mathematicians observe in Birds with Astonishment; whereby their Center of Gravity always remains in their Breast, below the Rise of their Wings, and which alone enables them, whilst floating in the Air, without any manner of trouble, to dispose their Wings, Legs, and other Joints for the most convenient Uses. Thus we see that the strong Muscles with which they move their Wings, are inserted in their Breast; insomuch, that even that Muscle which raises the Wings, and which one should otherwise have expected to have found in the Back, is likewise seated in the Breast, and is carried through a Hole expressly made for it after a wonderful manner, to the Legs, in order to perform its Function: Concerning which, see the foremention'd *Borelli*, Prop. CLXXXIV. where, besides what has been already said, those that please to consult that learned Work, will find a great deal more to convince them of the adorable Wisdom of Him that has created all kinds of Animals.

To instance in one Thing that seems almost incredible; Could any one imagine that the Force of the Muscles whereby the Wings are moved, is ten thousand times greater than the Weight of the Bird that flies with those Wings; and if one desires to be more fully satisfy'd thereof, with an intent to admire the Greatness of the Creator, he need but consult the aforesaid Author, Prop. CLXXXIII, and CLXXXIV. We have already given a brief Demonstration of the amazing Strength of the Muscles of Men, so that this will not seem incredible to such as understand what has been there represented.

SECT. XXII. *Convictions from the foregoing Observations.*

I NOW ask again, whether any one (that reflects upon all that has been here said about Birds, and comprehends how many things concur to the same End, and to the most proper Purposes within so small a compass as that of a contemptible Bird) can imagine that this Creature is formed without Wisdom, and disposed as he finds in all its Circumstances? Let him view with this Knowledge a Sparrow, a Finch, a Canary-bird, or any other of those little Creatures, and then ask himself, whether it be conceivable, that in the little quantity of Matter of so small an Animal, such numberless Instruments were form'd by chance; of which some of them serve for Eating, for Digesting their Food, in a word, for Nourishment; others for Generation; some for Walking; others for Flying, and all of them so exactly adapted to their particular Ends, that the most learned Mathematicians and Naturalists of this Age, that have taken the trouble to enquire into the same, have very often expressed themselves thereupon with Wonder and Astonishment.

SECT. XXIII. *The Preservation of Birds.*

NOW as the Wisdom of the Creator shines forth in the Structure of the Birds, so likewise his Providence and Goodness in preserving many of them, is not less clearly manifested. The great Saviour of the World, endeavouring to dissuade his Disciples from taking too great care for Food and Raiment, mentions these Creatures for a Proof of what he would have them understand thereby: These are his Words, *Matth. vi. 25, 26. Take no thought for your life, what ye shall eat, or what ye shall drink; — Behold the fowls of the air; for they sow not, neither do they reap, nor gather into barns; yet your heavenly Father feedeth them: Are ye not much better than they?* Could the greatest Logicians have used any stronger Arguments in the world, to shew so palpably the Care and Providence of a GOD? In case he had spoke of Tame Creatures, one might presently have answered, that Men who make use of them, provide them with Food, as in the Case of Horses, Kine, Sheep, and the like. And as for the Wild ones, it might likewise be said, that they are able to fall upon what they meet with, and convert it to Food, such as Lions, Bears, Tygers, and the rest. If he should speak of Fishes, no body can shew that they ever suffer Want in the Waters: If of Ants or Bees, these gather their Food against the proper Season: If of Caterpillars, Silk-worms, and such other Insects, it may be answer'd, that in order to continue their Species, tho' their Lives are mostly limited to one Summer, their Eggs rest in the Winter, in order to produce their little Ones with the approaching Warmth, against the time that their Food is ready for them. But that for Ravens, and other Birds that live in desert places, and that would otherwise perish for Hunger in a few Days, their Food should always be so seasonably provided; and that for other defenceless, fearful little Animals, that run away from every thing, such as Sparrows and the like, their Food should be provided even at such times when they seem to be deprived of all Means of meeting with the same in the midst of a hard Winter, and when no Man himself, tho' never so ingenious and laborious, could instruct them how to find it (and much less meer Chance.) All this, I say, is a most manifest Proof of a great and adorable Preserver, as it is likewise of the Truth of the following Text; *Matth. x. ver. 29. Are not two Sparrows sold for a farthing? and one of them shall not fall on the ground without your Father. Or, as it is expressed in Luke xii. v. 6 not one of them is forgotten before God.* I leave it then to an Atheist himself to judge, whether he can ascribe the Manner after which these little Birds, contrary to all Appearance, are kept alive every Year, with a safe Conscience, to Chance only.

SECT. XXIV. *Transition to the Fishes.*

ASK now the Beasts, and they shall teach thee; and the Fowls of the Air and they shall tell thee: or speak to the Earth, and it shall teach thee; and the Fishes of the Sea shall declare unto thee: Who knoweth not in all these, that the hand of the Lord hath wrought this? In whose hand is the Soul of every living thing, and the breath of all Mankind. These were formerly the Emphatical Words which
Job,

Job, ch. xii. v. 7, 8, 9, 10. made use of against those that doubt whether there be a Wise and Powerful GOD. I do not produce 'em here to convince an Atheist whilst he has no respect for this Holy Word, but only that these miserable Men may once again silently examine themselves, whether what has been said before about the Birds, cannot move 'em to observe the Truth and Wisdom of those Expressions; and if that will not entirely satisfy them, let them pass on with us to the *Contemplation of the Fishes.*

SECT. XXV. *The Miracle of Fishes living under Water; and Convictions from thence.*

WE shall not here repeat what has been said concerning the Fishes in the *Contemplation of WATER*, nor prove more fully from thence the Goodness of the Creator, who has filled those mighty Caverns of Seas and Rivers with all Kinds of Fishes, to the end, that those vast Spaces should not remain useless; which Fishes, in some Countries serve for Bread, in others for Dainties; and by their variety, are fitted to gratify the different Palates of Mankind. Now let one of these most Conceited Philosophers, that thinks every thing is made without Wisdom, tell us, whether he could ever have believed, if he had not known it, that there were such things as Fishes, and that any one spoke Truth to him that shou'd give him an account, that in Water, in which other Creatures can remain alive but a very short time, there was found a particular Kind of Animals that could live, move, procreate, and perform other Animal Functions: And upon seeing a Fish perform all this in the Water, whether he could help taking it for a Miracle. And, which is more, whether he could, tho' his Life were at Stake, and tho' he had consulted all the wisest Men in the World, tell how a Fish must be formed, to be able to preserve itself in Water, and what would be the difference between its Blood and other Humours, and those of Animals that live in the Air.

SECT. XXVI, XXVII, and XXVIII. *How Fishes balance themselves in and against the Water, illustrated by several Experimentes.*

BUT not to dwell upon such general and well-known Reflections, let us pass on to some Particulars; to enumerate all would be impossible: How a Bird, only by the great Force and Motion of his Wings, does at the same time support itself, and fly forwards in the Air, has been lately shewn; but can any one observe, without Amazement, how a Fish raises its Body up to the Superficies, and again subsides to the Bottom of the Water, with hardly any visible Motion, or floats in any Part of it, without either rising or falling.

If there were in Fishes a settled and unchangeable Gravity, not much differing from that of Water, when they pass from Lighter to Heavier, that is to say, from fresh to salt Water, they would emerge, even in spight of themselves; and on the contrary, passing from Salt to Fresh, they would subside in the same manner, just as we see that an Egg will sink in fresh Water, and swim or float in salt Water or a strong Pickle, as is known even to the Women. So that to render the rising and sinking, and continuing in the

the same place in the Water, practicable to Fishes, without using the Force of any External Motion, it seems necessary, that according to particular Circumstances, their Gravity, with respect to an equal Bulk of Water, should be augmented and diminished; the rather, because the several Waters in which they are found, are oftentimes render'd lighter or heavier, not only by more or less Salt, but also by the mixture of other foreign Bodies.

Now let a Sceptical Philosopher ask himself, whether he can imagine that it is without Design, that the Structure of most Fishes do compose the most wonderful and proper Hydrostatical Machines; whereby, according as they have a mind to a emerge or subside, according as the Water is lighter or heavier, they may diminish or increase their relative Gravity?

To be satisfied herein, we need only open the Bellies of a Carp, a Bream, a Roach, an Eel, and many other sorts of Fishes, and we shall find therein a little Bladder, like B D (*Tab. XVII. Fig. 5.*) which is serviceable to them in all the aforesaid Purposes.

To give any one a Notion thereof, who reads this, only for the first time; let him suppose a Fish M C (*Tab. XVII. Fig. 6.*) lying in the Water; the Bladder whereof D B appears in its Belly at *q*; and is so far expanded by the Air within it, that the Fish and it together are just as heavy as an equal Bulk of Water E F; by which he will know, if he understands any thing of the Principles of Hydrostaticks, that this Fish will stand still in whatever Part of the Water it is plac'd, without rising or falling, so long as it hinders either by the Muscles of its Belly, or perhaps by those of the Bladder itself, the Air within it from expanding itself farther, and rendring the Cavity of the Bladder larger.

But so far as the Air that is in it continually endeavours to expand itself, the Bladder B D will be more dilated, and become greater, when the Muscles cease to contract it so strongly as in *b d* at *p*; and the Fish having so much more Emptiness in itself, will become lighter than an equal Quantity of Water; and therefore so long as that lasts, continually emerge or ascend, as in the Figure from *q* to *p*.

Finally, since the Air may likewise be compressed and squeezed together; and being so on every side, will lye in a narrower Compass than before, if the Fish M C, by the contraction of the said Muscles, presses the Air inwards, and renders the Bladder B D smaller; it is plain from the Laws of Hydrostaticks, that the Fish will thereby become heavier than a like Quantity of Water, and consequently subside from *q* to *d*.

To present the Reader with a grosser Idea thereof, we need only suppose a Lad swimming and supported by two Ox-Bladders blown up; in which case it will be easie to conceive, that if he could dilate and contract the Bladders at pleasure, when they were very small, he would sink, and on the contrary he would float when they were large; and if he could readily find upon a measure between both, whereby he could render the Bladders too large for sinking, and too small for floating, he would be able to stand still in any part of the Water.

A remarkable Proof that these Bladders are of the same use to Fishes, may be found in the XXIX. *Prop. of Borelli*, where he relates, that after having kept a Fish in a place exhausted of Air, so long, till that the Air which was in its Bladder finding no Passage to go out fast enough, nor any Resistance of the external Air, did so far dilate itself, that the Bladder was burst thereby; after which they threw the said Fish into a Pond, where during the space of a Month that it lived, it could never raise itself up with swimming, but was always found creeping like a Snake at the bottom of the Pond.

Among my Experiments, I find one that seems to give some Light to this Matter, which was as follows; we took two Gudgeons, and put 'em into a Glass Receiver in Water, and thereupon exhausting the Air, we observed them to emerge, without being able to get downwards; after which they swelled in such a manner, that their Eyes stood out of their Heads, and afterwards suffer'd several Convulsions; but by letting in a little Air again, their Eyes sunk as suddenly: both which Appearances happen'd every time that the Air was drawn out or admitted, without their contributing any thing thereto by their own Motion.

The Reason thereof was, because the Air dilated itself in the Bladder at the same time that the external Air was exhausted from the Receiver: So that the Bladder becoming larger, the Fish was lighter than so much Water, and emerged; but the Air being let in again, and the Bladder being pressed by it, and becoming smaller, the Fish was heavier again than an equal Bulk of Water, and so sunk down.

To make the thing appear yet more visible, we took a little Hog's Bladder, in which there was very little Air, tied a little Stone to it, to make it sink in the Water under the Receiver, and we let the Bladder that was taken out of one of the Fishes, float upon the Water; whereupon we perceived, that by one Draught only of the Pump, the Fish's Bladder presently dilated itself, and the Hog's Bladder, to which the Stone was tied, ascended and floated upon the Water; but on the contrary, by letting in the Air again, both the Bladders shrank and became smaller, and the last sunk down; which shew'd the Action of the Air in the Bladders of Fishes, as is above represented with great clearness.

Another Experiment proved the same no less agreeably: We fill'd a little Bottle A (*Tab. XVII. Fig. 7.*) so far with Water, that being inverted, there remained a little Air upon the Water at A; but being put loose into a great Vessel of Water, it sunk down. But after having put this great Vessel M N Q P under the Receiver of the Air-Pump, and drawn off the Air that pressed upon the Superficies of the Water M N, the Air that was in the little Bottle at A, missing its Resistance, did remarkably and visibly dilate itself; upon which forcing the Water out of the said Bottle, it made the Bottle rise up to B; but upon restoring the Pressure of the Air upon the Water at M N, the Bottle sunk again, because the Air at B was thereby compressed into a smaller Space, and the Water returned into the Bottle, and made it heavier again. This, if the Bottle be not too full of Water at first,

may be repeated as often as you please, by every lifting up and letting down of the Sucker of the Pump.

SECT. XXIX. *The Effect of Cold and Heat, and of a greater or lesser Column of Water pressing upon Fishes, shewn Experimentally.*

BUT now in case the Air contained in the Fishes Bladders should be always the same, and the Quantity thereof unalterable, we know that by the Gravity of the Water, and according as the Pressure thereof is greater or smaller, the said Air would be more or less compressed, as it happens likewise by Cold or Heat; the Consequence of which would be, that the Fishes would be driven upwards or downwards oftentimes against their Will and Convenience.

To give an Instance hereof, in case of Heat or Cold, and to shew the Proof of this Supposition, we need only let so much Water run into the aforesaid little Bottle (*Tab. XVII. Fig. 7.*) that it may sink very slowly and gradually, without much over-balancing the external Water, and remain lying at A. Then set the Vessel M N Q P, either by the Fire, or in the Sunshine, whereupon the Air at A dilating itself by the Warmth of the Water, will drive out a little Quantity of the Water that is in the Bottle; and the Bottle becoming lighter thereby, will rise up to D; but if you let the external Water cool again, the Air will be compressed and reduced to a smaller Space in the said little Bottle, and the Water flowing into it, will sink it again down to A.

But to shew likewise, that the same Effect may be produced by a greater Depth or Column of Water; and that the Air in the Bottle may be more compressed without a greater degree of Cold, than when the Bottle is nearer to the Superficies of the Water, take the Bottle E, and by putting more or less Water into it, you may bring it to such a Weight, that when you let it go, it will float upon the Superficies of the Water M N; but by a Thrust, or with the addition of never so little Water, it will sink down: Now if you take a Stick and thrust the little Bottle E down to O, you will see it continually sinking there, tho' you should raise it a little up; and again, when it is raised up to about M N, you will see it continually floating upwards, tho' you should thrust it a little down. And it may likewise be often moved in the middle this way and that way, between N and P horizontally, without either rising or sinking, if you can find the exact Middle D; and holding the Bottle with the Stick against the Side of the Vessel till it be quite still, it will remain in the very place you leave it.

Those that understand Hydrostaticks, know the Reason thereof; and those that do not, may learn them in *Contemplation XXVI.* Those Reasons are, That the Bottle being at O, is driven down with a Force, as FR, and upwards with another, as FS; but being at D, the Force FH presses it downwards, and FI upwards. From hence we see, that this Bottle is every where between two Powers, pressing against each other, which are greater when at O, and both of 'em gradually less when it is at D, or yet higher: Wherefore the Air at O, suffering a greater Pressure than at D, and being

likewise

likewise more contracted or pressed together, the Bottle is fuller of Water, and consequently heavier at O than at D or E; it must therefore sink at O, rise at E, and at D remain in an Equilibrium, that being supposed the place where the Bottle, with the Water and the Air it contains, taken all together, is equal in Weight to a like Bulk of Water out of it.

Now if instead of this Bottle we suppose a Fish with its Bladder, in which so much Air is included, that in Winter the Fish by the Expansion thereof may emerge; and when arrived to the Superficies of the Water, may with little trouble contract its Bladder, and the Air within it, after such a manner, as to remain where he is, or to be able to sink down again: In such a Case it is plain, that a hot Summer following, this Air, the Expansion whereof was sufficient in Winter, being still the same in Quantity, will dilate itself much more strongly by the Heat, and hinder the Fish, unless he constantly exerts all his Strength, from being able to descend again.

The same Inconvenience would happen if there were less Air in the Bladder, and only so much, that the Fish might easily support itself at Top of the Water in Summer; for upon the return of Winter, or upon a Fish's descending lower, and meeting with more Cold, and a greater Pressure of the Column of Water upon it, and by both these Means, the Bladder being contracted without any Concurrence on the part of the Fish, much Strength must be used to raise it up again; insomuch, that with the change of the Seasons, the Fish wou'd oftentimes have too much Air in the Summer, and too little in Winter: So likewise the Fishes passing into Water of different Gravities, would be many times furnished with too much or too little Air in their Bladders; and in order to avoid all these troublesome Alterations, and to pass conveniently from one place to another, they would be obliged to remain always in a Water of about the same Weight, and as much as possible in the like Depth and Temper, as to Heat and Cold.

To prevent all these Inconveniences, the readiest manner seems to be, that the Fishes should be endowed with the Faculty of encreasing or lessening the quantity of Air in their Bladder, according as occasion required, which likewise we see happen by the Wisdom of the Creator; forasmuch as their Bladders have a Communication with their Stomachs by the Means of a very small and narrow Tube; so that they can diminish the Air by discharging from the Bladder thro' the Mouth, and increase it, by drawing it in again; about which *Borelli, Prop. CXI. Part I.* has this Observation, That the Bladder is empty when the Fish being in *Vacuo*, discharges a great many Air-bubbles by its Mouth; and the swallowing in of Air may perhaps be the reason why we often see the Fishes moving their Mouths in the upper Part of the Water near the Air.

SECT. XXX. *Convictions from the foregoing Observations.*

Now if a deplorable Atheist has taken the Pains to read this, and understands it, let him tell us, whether it can any ways seem probable to him, that so many Laws of the Water, of the Air, and of the Motion of the Muscles in Fishes, are so accurately observed by meer Chance? Or could

blind Nature, ignorant in itself of all its Effects, produce such a Difference, as on the one hand to furnish the Fishes with such a Bladder, and Birds on the other hand, tho' they likewise move in a fluid Matter, or in the Air, with quite a different Method of Progression; since such a Bladder by which a Bird were to be raised up, must be lighter than the Air, and for that reason empty of it. Now they who ever proposed to raise a heavy Body in the Air with a Globe out of which the Air is exhausted, know first, that the Shell of it must be made pretty thick, least, being thin, it should be unable to resist the Pressure of the external Air upon any Accident; and besides, tho' all this were not observed, yet it must be of so disproportionate a Magnitude, that no Bird, being incumber'd with it, could be able to fly: Not to take notice, that the Greatness of a hollow Brass Globe (that being empty of Air without lifting up any heavy Body, it might ascend alone, and of itself) is computed by Mr. *Leibnitz*, in the *Philosophical Transactions* of *Berlin*, published in the Year 1710. p. 127. to be such, that the half Diameter thereof would require to be above twenty thousand times longer than the Thickness of the Metal of which the Crust of the said Globe must be composed; so that the said Globe being an Inch thick (tho that perhaps would not be sufficient to resist the Pressure of the external Air) the whole Magnitude of this hollow Globe would take up some thousands of Feet. I have expatiated here something the more, to convince Sceptical Philosophers, that are any ways versed in Modern Experiments, that the Structure of Fishes is entirely opposite to what is proper for the flying of Birds; and that it is undeniable, that in order to make Fish and Birds move upwards and downwards, (each of 'em in their different Fluids) different Means must necessarily be applyed; which being performed in both in a manner so suitable to all these Circumstances, I leave it again to their own Judgment, whether this does not plainly shew the Wisdom and the good Pleasure of a Great Creator.

SECT. XXXI. *Fish Swim with their Tails.*

NOW if we observe farther in so many Fishes, that in order to their Progressive Motion in Water by Swimming, they do not make use of their Fins as Oars to row with, nor after the same manner as the Birds do their Wings in the Air, but by the help of their Tails, much after the same manner as a Boat moves when they put an Oar out at the Stern, and paddle with it backwards and forwards.

Is there no Wisdom to be discover'd in this (since Fishes stand in need of no external Motions for raising and sinking their Bodies, as we have shewn before) that their Instruments are so formed, that no time should be lost in their advancing forwards? And that having made a Motion with their Tail, by which they are protruded, they have no occasion to draw it back again, in order to dispose the same, to repeat the said Protrusive Motion: This the Birds are forced to do with their Wings, that they may strike upon the Air every time perpendicularly, in order to support themselves therein; but the Fishes by putting their Tail in its former Place and Disposition,

sition, exert the same Force on the other side, which contributes as much to their Progression as the first Stroke had done? Is it now by Chance, that these Tails, like the paddling Oars, are broad at Bottom, that they may act with greater Force upon the Water; and that they are composed of a strong Membranous Matter, which is however flexible; that the Muscles of the Back are of such a Structure, as to move the Tail with a sufficient Strength, even so far, that the Violence which the larger kind of Fishes, such as Whales, exert therewith, is so terrible, that one can hardly read the Accounts thereof without being amaz'd?

SECT. XXXII. *The Use of the Fins.*

BUT forasmuch as in all Bodies that float in Water, the heaviest Part always tends downwards, according to the Laws of Hydrostaticks, would it not likewise follow from hence, that since the Backs of Fishes, quite contrary to those of Birds, are the heaviest Part of their Body, they must always turn their Bellies upwards in the Water, as it is commonly observed to happen in dead and floating Fish, since their Bladder cannot be then compressed, but the Air being dilated therein, makes the Fish float and turn its Belly upwards, the Back being not only heavier, but the Belly also lighter by such Expansion of the Bladder than when the Fishes were alive.

Can it then be imagined that the Wisdom of the Creator did not foresee this in the Forming of Fishes, to which He has given two Fins under their Belly, by which they support themselves upon the Water, and by giving them the Faculty of Swimming whilst alive with their Bellies downwards? Of which we may find an accurate Examination in *Prop. CXIII. of Borelli*, who having cut off all the Fins under the Belly of a Fish, and in that Condition thrown it into the Water again, found it continually staggering on one side or t'other, without being able to support itself in the natural and common Position of Fishes.

But besides this, to the end that the Fishes might be provided of every thing that is necessary for them towards Swimming, it seemed to be still wanting, that they should be able conveniently to stop that Progress which they had acquired by their Tails, and to be able to turn to the Right or to the Left in their Course, neither of which could be done by the Tail but with great Trouble. For this Purpose we find the Fishes provided with two Fins on the Sides, by which, when they extend 'em both together against the Water, their Motion may be stopt; and if they stretch out one, and keep the other close, they may turn to that side whence the Fin is displayed; just as we see happen in a Boat, which turns to that side where one Oar is thrust out in the Water to stop its Progress.

SECT. XXXIII. *Creatures that live in the Air, see confusedly in the Water.*

IN Case this does not yet suffice to convince a Sceptick that there is a GOD proposing to himself a wise End in all his Designs, let him reflect upon what follows, which seems to be capable of removing all farther Uncertainty.

It is known to every one that ever div'd under Water with his Eyes open, that one may indeed see the Light and many Colours of Objects, but that all will appear Confused and without Distinction. Now we have shewn before in *Tab. XI. Fig. 2.* that the Rays of Light *BC* and *BC* coming from a Point *B* into the Air, continually diverging or spreading wider and wider from each other, meet in the Eye with a watry Humour, thro' which they do not then proceed directly from *C*, according to *gg*, but are refracted towards each other at *CD*; which refraction or bending being repeated again the second and third time at *D* and *E*, they both of 'em unite again at the Bottom of the Eye at *b*; in which manner of collecting all the Rays proceeding from *B* into this one Point *b*, all the Exactness of a good Sight consists.

Let us now suppose this Eye, as also the Point *B*, in the Water; then the Rays *BC* and *BC*, will come out of the Water upon the Aqueous Humour *CC*. And since, in order to be bent or refracted, they must likewise change the Medium thro' which they pass, these Rays therefore remaining in the said Medium or Water, and passing to *C*, will not be broken or bent to *DD*; but proceed directly to *g g*, till they meet the Crystalline Humour *ST*: So that altho' they be refracted after the usual Manner, thro' the same at *D* and *E*, yet failing of the first Refraction at *C*, they will not be able to approach near enough to each other, in order to be collected just at one and the same Point *b*, which is at the Bottom of the Eye: But this Point of their Collection will fall farther behind the Eye, for Instance at *k*; for which reason every Point, as *B*, with its Rays, will fill the whole Space *mn* at the Bottom of the Eye; which happening in like manner from the other Points of the Object near *B*, the Rays of these several Points will be mingled together at the Bottom of the Eye, even in the same Space between *m* and *n*, and so occasion an entirely distracted or confused Sight, because each Point *B* is not seen in a particular Point *b*; after the same manner as in a dark Chamber, when you hold the Paper a little too near to the Glass, the Objects painted upon it are all confused; whereas by holding it at a due Distance, it represents the most accurate Painting that Eye ever beheld.

SECT. XXXIV. *To prevent this confused Sight, Fishes are endowed with rounder Eyes.*

NOW this is the Inconveniency that would happen, and be peculiar to all Fishes, if their Eyes were of the same Figure with those of such Creatures as live in the Air. Now in Case any one that should doubt of the Wisdom of GOD in the Formation of Fishes, does understand the Laws of Opticks; and if he were to tell us how this Inconvenience in Fishes might be prevented, and how they could be furnished with a distinct Sight; such his Skill in Opticks might indeed teach him some of the Methods whereby the same might be brought about; as for Instance, by holding a round Glass before the Fishes Eyes, as old People do, who find the same Defect in their Eyes, because they become less round and more flat by Age: but it is plain, that such a thing can't be done for the Fishes. The making their Eyes longer, so that they might be extended not to *b* but to *k*, would indeed render their Sight more distinct;

distinct; but then it would bring along with it this Inconvenience, that their Eyes, by losing so much of their Roundness, could not easily be turned to all Sides. And, to pass over others, let him tell us, whether he could have thought of a shorter Way, than by making the Crystalline Humour of the Fishes S T rounder, and of a smaller Circumference than the Eyes of those Creatures that live in the Air; and he will know, that according to the Rules of Opticks, this will be sufficient to make good the Defect, and cause the Focus of the Rays to fall so much nearer upon the Crystalline Humour.

Now this is what we really find in Fishes, in which the said Humours are sufficiently Convex, and like little Globules, as may be daily observ'd in the Eyes of boiled little Fishes; and as appears even in the Eyes of great Whales, which are very small and round, and which if they were larger, and consequently of a flatter Circumference, would take up a great Part of their Heads for the Use of their Sight, which now is contain'd in less Room.

Now let those self-conceited, but unhappy Philosophers, who deduce every thing from meer Chance, or from ignorant or necessary Laws of Nature, retire within themselves, and reflect, whether it can seem probable to them, that it is perfectly accidental that besides the wonderful and uniform Structure abovemention'd of the Eyes of all Animals, those that belong to the Water have their Eyes so form'd, as to see and distinguish Objects in that Element; and those that live in the Air, have theirs likewise adapted to this Element. Or let them, with all their fancy'd Wisdom, prove to us the Necessity, according to which they can infer from the Nature of the Water, that (unless the Creator had had this End in view) the Eyes of Fishes would have been always rounder than those of the Creatures which belong to the Earth or the Air. But as this is not possible for them to do, let them confess with us, and besides with so many Men famed for Learning, that a GOD of Wisdom and Goodness extending his Care even to Fishes, does visibly appear in this matter. Or if they still persevere in their Opinion, they must pardon us, if we say we are compell'd to think that they are to be pitied, as lying under a secret Judgment of GOD, as well as a natural Blindness, especially if they go on to affirm, that after having duly weigh'd all things, they still remain unconvinced.

I have dwelt a little the longer upon this Subject, because one of my Acquaintance, who being involved in Doubts, and having entertain'd some Scruples about the most important Truths, by much (but wrong) Philosophizing, happen'd to read these Observations in *Robault's Physicks*; whereupon he felt great prickings and trouble in his Mind, and presently own'd that he was now fully and irrefragably convinced that the Eyes of all Animals, and especially the diversity in the Form of those of Fish, could not be produced without a manifest View and Design of Him who made them; and consequently that there must be a GOD, who by causing his Wisdom to appear to all Men by his Works, deserv'd to be fear'd by all his Creatures. May He grant, that all those who shall read this, and seriously reflect upon it, may likewise be convinced!

SECT. XXXV, and XXXVI. *The Fruitfulness, and Numbers of Fishes.*

THAT we may be more confirmed in the Acknowledgment of a GOD, we need only contemplate the Multiplication and Fœcundity of Fishes, which happens in many Kinds of them after so wonderful a Manner, as has been shewn already upon another Occasion; some of the Females discharge their Spawn, and the Males their Melt or Seed in the Water near each other, and without any farther Acting of the Fishes on either side, both these Seminal Matters being entrusted to the Water, do produce Young Fishes of the same Kind.

Now can any Body imagine that this Spawn and Melt of the Males and Females, together with the Water, have the Property of Engendering Fishes after such a manner by meer Chance, and without a wise Design; the rather, since we see that herein is a Direction or Disposition of propagating the Species of Fishes above all other Creatures in an infinite Number; for if there were not some other extrinsical Impediment, every single Grain or little Egg that we find in the Spawn, would become a Fish. So that it is no wonder what some Travellers relate concerning their Fruitfulness; as for Instance, that in the Island called *John Fernandez*, in the *South-Sea*, there is such a vast Quantity of Fishes, that one Man can in one Day catch enough to feed 200 Persons.

I have often thought of the Text in *Genesis* i. 20. *And God said, let the Waters bring forth ABUNDANTLY the moving Creature that hath Life*; whereby the two aforesaid particular Properties, concerning the great Encrease of Fishes, are as one may say, pointed out with the Finger; the rather, because in the 21 Verse it is repeated with the same strong Emphasis, *which the Waters brought forth ABUNDANTLY after their Kind*.

Now that this has respect to Water, which, as a second Cause, produces these Fishes out of their Spawn, seems to be deducible from hence. That the Procreation of Birds being mention'd in the said Verses, is not ascribed to the Air, tho' they live and are produced therein, as Fishes in the Water; as also, forasmuch as afterwards mention is made in the 24th Verse, of the Earth (of which all Creatures do at present consist, since all of 'em receive their Food from thence) after a different Manner: And moreover, how much this first Command of the Creator does continue firm, and prevail even to this very time, appears especially from hence, that in both the quoted Places the Expression of *bringing forth abundantly*, is only found in relation to Fishes, but not at all mention'd concerning Birds and Beasts, tho' they are compared with one another in this same Chapter. Now that the Fishes do multiply in much greater abundance beyond other Creatures, even to this Day (tho' an abundant Production is likewise ascribed to other Places where there is no Comparison; and in *Genesis* the viii. and 17. and the ix. and 7. the same radical Word is used) at least that they can be more multiplied, is obvious enough, from the prodigious Quantity of Eggs in their Spawn, and from other Relations that have been hinted at above. Thus in *Pf. civ.* they are said to be *innumerable*; and upon the same Foundation *Jacob* wishes that *Ephraim* and *Manasses*

nasses may grow into a Multitude (or, as it is in the Margin of that Text, *as Fishes do encrease*, Gen. xlviii. v. 16.) At least it is plain from hence, that those Words were not spoken without a Fundamental Knowledge of the Properties of Fishes, as two great Circumstances in which they differ from other Creatures, namely, the Effect of Water in their Production, and their great Fecundity.

SECT. XXXVII. *The Curse appears from the Production of Fishes.*

THERE may still one Remark be made about the foregoing Matters; namely, that this so great Multiplication of the Fishes, which seems to be the necessary Consequence of the Quantity of their Eggs, is not however observed to be so at this time. Now such as allow the above-mention'd Text to be the Word of G O D, may discover herein the Force of the Curse, which after the Fall of Man is extended to all things; for the sake of which not only the Trees are less Fruitful than from their Contexture one might have expected them to be (of which hereafter more largely) but Men likewise live a smaller Space of Time than their Structure seems to promise (of which something has been said above in *Contemplation XII.*) Now if this be seriously consider'd by a Sceptical Atheist, it will not be easy for him to assign any other Cause besides this Curse for the same, nor to remove the Difficulty which offers itself, that so many Things, and among them the Fishes, do not answer the Expectation which we might justly entertain from their Structure; and which is more, have not in so many Ages answer'd the same, tho' every thing be compleatly disposed thereto.

SECT. XXXVIII. *Creeping Creatures not yet thoroughly known.*

NOW how the Creeping Creatures, such as Worms, Snails, &c. do move from one place to another without Legs, and other external Instruments, has not (that I know of) been yet examined into with so much Accuracy, as to enable any one to say any thing satisfactory about it; he that desires any account thereof, and how, according to the Opinion of the great Mathematicians, such Motion may be perform'd, let him consult *Borelli* in his Book about the Motion of Animals, *Part II. Prop. XIII.* Mr. *de la Hire*, in his Treatise of Mechanics, §. CXII. p. 358. seems to have carried his Observations upon this Matter somewhat farther, affirming, that in great Worms, such as are found in the Sea, the Muscles can be discover'd, some of which encompass the Worms like so many Rings, others are extended lengthwise in the said Worms. Now if this latter sort be so form'd as Mr. *Borelli* describes them, the Serpentine Motion of Worms seems to be performed by those Muscles; since when the long Muscles are contracted, the Worms becomes shorter, and when the round ones, it is stretched out in length. But so far as the Structure itself of these Creatures does not seem to have been sufficiently enquired into, we shall be silent about it, that we may (as much as possible) avoid substituting Conjectures, tho' of very learned Men, and proposing them to any one, instead of the true Works of the Creator. This only would I ask of any one that does not

own a GOD, whether it can appear reasonable to him, to suppose that a Worm is made without Wisdom, when so many learned Gentlemen, tho' urged to give an account thereof, must acknowledge it to be a very difficult Question.

SECT. XXXIX. *Insects, Silk-worms, Caterpillars, &c.*

NOW if we pass on to the Examination of the surprising Structure of so many different Kinds of Shell-Fish, both great and small, and yet farther of Caterpillars and Worms, and of the Aurelias proceeding from them, and of Flies, Grasshoppers, Beetles and the like, with which at present the Closet of Persons of Distinction (that delight themselves in contemplating the surprising Works of the Great Creator) do with laudable Charge and Pains abound, and wherewith a great many Books besides are filled, without near comprising all the Kinds thereof; to produce many Instances thereof will not be necessary here, since they are to be found in so great a number elsewhere.

But to instance in two or three of 'em; ask any Body, be it who it will, whether he can think, that it is by meer Chance that a Silk-worm comes out of an Egg furnished with all the Instruments for Moving, Eating and Digesting its Food as other Animals are; that afterwards Spinning itself up with the Silk that comes out of its own Bowels, it is turned into an Aurelia, from whence at last proceeds a Butterfly, which after Copulation with a Male of the like kind, lays Eggs again, which in the following Year become Silk-worms; this is known even to our Children that are wont to breed the same.

They that in Summer meet with so beautiful a Butterfly as is represented *Tab. XVII. Fig. 8.* flying with Wings, running with Legs, and furnished with all the necessary Parts for Nourishment and Generation; when they read in the Observations of the accurate Mr. Goudart, that the said Creature was a Caterpillar B before, and that it was first turned into the Aurelia C, and afterwards became a Butterfly; could they seeing such Metamorphoses, and Change of Figures in so many kinds of Animals as are briefly named above, and of which the said Author faithfully reckons up a great number; could they look upon 'em, I say, otherwise than as so many Wonders of a great and wise Creator? Or can they persuade themselves, that all this is brought about by Causes divested of Understanding and Knowledge? And the rather, forasmuch as the little Eggs of those that we know are found by Experience not sooner to disclose their young Ones, than till the Herbs and Leaves that are to serve them for Nourishment, do spring out of the Ground or Trees. Now if this be true, as several Naturalists pretend they have observ'd, let an Atheist see whether he can calmly persist in that Opinion, that there is no room for an End and Design of a great Preserver. And if the same has place here, and that there is undoubtedly so great, so adoreably Wise and Powerful GOD that governs all Things, woe be to them, yea, double woe to all that deny Him.

SECT. XL. *The Consideration of small Animals in general.*

To return to the Matter again; Since these Insects, together with Shell-fish, have been consider'd with great Diligence by many learned Men, every one may find Matter of Astonishment in what has been transmitted to the learned World concerning the same; and I hope that this happy Beginning, which Men of Note and Judgment have made, may in process of Time be an Inducement to great Minds to contemplate these small *Animals* in certain other Views, and to enquire farther into the Wisdom and Art that do so manifestly appear in the Instruments which they use for Motion, Nourishment, and all external Sensation; by which particularly the Glory of their Great Creator (which does not appear less in the Structure of a Fly, a Flea, or a Mite, than in the making of the biggest Elephant) may be demonstrated by yet stronger Arguments against those that refuse to acknowledge the same.

He that doubts hereof, let him consult those great Enquirers, who by the help of their Microscopes have discover'd as it were a new World, and thousands of otherwise invisible Creatures; in the unconceivable smallness of which, not only the Desires of a curious Eye will meet with intire Satisfaction; but likewise the manifest Designs of the Creator and his Wisdom and Goodness, (even with respect to these *Animalcula*, that by reason of their Smallness are almost invisible) will shine forth as clear as the Sun.

SECT. XLI. *The Eyes of a Beetle, and Convictions from thence.*

FORASMUCH as whole Books have been writ upon this Subject, I shall only give an Instance in the surprizing Structure of the Eyes of a *Beetle*, the like of which we also find in Flies. The Great Creator, in the Formation of this Insect, thought fit to make the Eyes thereof immoveable, which in bigger Creatures can be turned to all Sides; shewing thereby, that He does every thing according to his good Pleasure, and will be bound to no Laws. Now it is certain, that these Beetles and Flies, not being able to turn their Eyes, can only see that Way towards which the opening of their Eye is directed; but because the bountiful Preserver of all things does likewise extend his Goodness even to these most contemptible Creatures, and that they may be aware both of the Birds, and other Perfecutors that prey upon 'em, and use them for Food; and that they may spy them not only before, but sidewise, and likewise behind, in order to their Preservation, he has been pleas'd to cause their Eyes to stand out of their Heads, with a Protuberance or Convexity, and bestowed upon 'em such a Figure in a manner as we find in Glasses, which being ground with many and different Faces, do multiply the Object as many times as there are Superficies upon the Glass; So that each of these little Planes or Superficies of the Eye do appear thro' a good Microscope to be an exact Hexangular Figure, as we may see in a Beetle's Eye (*Tab. XVIII. Fig. 2.*) A B C D, and in that of a Fly (*Fig. 3.*) G E F. They that look upon it in this Table, must be pleas'd to take notice, that it is represented here much greater than it really is, and so

as it appear'd through a good Microscope; whereas otherwise each of 'em are so small, that the Observer, Mr. *Leeuwenhoek*, having counted those that are in the Diameter of the Eye, justly concludes, that the number contained in the Superficies thereof does amount at least to 8000.

From this Structure every one may infer, that these Insects by the means of so many different and convex Superficies, are able to see upwards, downwards, sidewise, before and behind, as if they had so many Eyes, with as much Ease, and perhaps more, than any other Creature that can turn one and the same Eye every way.

One that is well versed in Dioptricks, and understands the Nature of Vision, might perhaps find this Defect in such a Structure; that in case these Insects must see like others, it would not be possible if the Superficies were flat (as in the polished Glass or Diamonds, to which they were compared) that the Rays passing thro' them from a Point, could be collected in a Point at the bottom of the Eye, which, as we have shewn above, is required to a distinct Sight, and which is besides, the Reason why the Eyes of Fishes must be rounder than those of other Creatures living in the Air: So that these Insects, according to the Laws of Vision, might indeed have a confused Sensation of Objects without them, but yet see nothing distinctly thereof, unless each of the said little Superficies were in themselves Convex. But can any one who justly objects this Difficulty, observe again upon farther Enquiry, without being amazed at the Wisdom of the great Creator, that each of these exceeding small Superficies are of a Convex and Globular Figure, to the end, that they may serve for a distinct Sight to each of these little *Animals*, according to the exact Rules of Opticks, as those that examine them more nicely and attentively will find. But forasmuch as the globular Figure cannot be compleatly shewn by the said Microscopes, let any one take the Eye of one of these little Creatures, and observe them nicely against the Light of a Candle, holding them at a little Distance from the Glass, and he will then discover as many Images of the Flame of a Candle inverted, as there are Superficies in the Eye of a Fly, all encompassing the middle Superficies upon which he looks as in a Right Line: Which burning Candles are so exactly delineated, tho' all exceeding small, that as the Flame of the Candle itself moves upwards, the Picture of it will appear to do the same every time, but inverted; just after that manner as one may see thro' a round polished Glass the Picture of a remote Candle inverted upon a white Paper; or otherwise looking thro' a double Microscope; as likewise by keeping ones Eye behind the Focus of a round Glass; in all which Cases one sees the Object turned upside down.

Now every Mathematician that is never so little versed in Opticks, knows that this cannot be done by a concave or flat Figure; and that, in order to shew the exact Image of a luminous Object inverted (which is here beyond Expectation every way distinct) a convex or a more protuberant Figure is only required; which cannot be doubted by any one that understands the Refractions of Light.

I must confess, that for my own Part, I could not oftentimes see and observe without Emotion, a Providence operating with the wisest Views even in the very smallest Things, and appearing not only so visibly, but so adoreably too in these small *Animals*. And since such a Figure would create trouble enough to the most skilful Glass-grinder, if he were to form a great and manageable Glass like it, how impossible would it be for any humane Art to extend itself so far, as to communicate such a Shape, and all the Properties belonging to Sight, to an almost invisible *Animalculum*. Now if these little Particles or Eyes were not transparent, there would be no Sight; if each of 'em were not round, there would be a Sight but confused; if they were not disposed in a convex Superficies, these Insects would not be able to see round about 'em, because of the Immobility of their Eyes; if the Membranes thereof were not supplied with Humours proper for them, and such as must be conveyed thither by unconceivably little Vessels, the Sight would be ruined by Dryness, as Experience teaches us when Eyes continue too long dry: Now all this is required, and all this is found in each of these Insects, and every one of these Circumstances is wonderful: Can we then see them all concurring in so small a Compass, and coolly affirm, that it is all by Chance?

Now every one that has seen the curious Structure of the Eyes of these so small *Animals*, in the Observations of Mr. *Leeuwenhoek*, or other Naturalists, or made the Experiment himself, may imagine, how overflowing the Wisdom of the Great Creator thereof is, who has vouchsafed to display so much Skill and Contrivance to render happy so many thousand Millions of such contemptible Insects (how much more then a rational Man) and to cause them to see distinctly!

SECT. XLII. *Something concerning the Beginning of Action in Beasts.*

MY Reader must not be surpris'd, that in this *Contemplation* of *Animals*, I have said nothing of the Principle of the Actions in Beasts; concerning which Philosophers differ so much among themselves, some of whom look upon Beasts to be no more then Clock-work, without either Sense or Understanding; but others think that another Principle of their Actions must be allowed, to enable Beasts to act as we see 'em.

The chief Reasons that have induced me to pass over this Matter in silence are, that both these Parties agree in owning a God, how much soever they differ in other Sentiments; wherefore, since we only write here for the Conviction of Atheists, we thought it unnecessary to engage our selves in this Subject.

However, to say one Word about it to unhappy Infidels: How much soever we see perform'd by Beasts that may appear surprising to us, and how much soever they may seem to mimick the Actions of Men, this is certain, that we could never yet discover any thing in them that was like any Sign or Character of the Knowledge of a God, or of his Service. Let then an Atheist learn from hence, that far from deserving the Title of a *strong Mind*, upon account of his deplorable Philosophy, the only Reward that

that he is like to receive for the Pains he takes therein (I say it with Compassion for his Blindness, and without Design of the least sarcastical Reflection) is, that it serves to distinguish him from a rational Creature, and in this Case, sinks him down into the Condition of a Beast, and yet without giving him this comfortable Assurance, that he is to expect nothing else after his Death, but to be reduced to the State and Condition of irrational Beings. And I leave him to judge for himself, (since there appears in Men the Knowledge of a God, but by no means in Beasts) whether the Opinion of Christians are so absurd, when they maintain, that Death does entirely annihilate Beasts, but that the Souls of Men do still remain; so far as the Knowledge of an eternal God does exert itself so much more adorably in a Being that is framed for Eternity, and so adapted to glorify that God for ever.



CONTEMPLATION XXIII.

Of Plants.

SECT. I. *Transition to Plants in general.*

NOW for the farther Confirmation of what we aim at in all these things, let us pass on to the Plants; and tho' a great many of them be still unknown, yet, what the Experiments of Enquirers have discover'd thereof of late Years, is sufficient to prove, that a wonderful Power and Wisdom does appear, in adapting them all to their respective Uses.

Now if we should take notice of nothing more than what is already sufficiently known both to the Learned and Unlearned, namely, that we see a little Seed first taking Root downwards in the Earth, and then shooting up a Trunk or Body in the Air, and in some producing Branches, and in others Leaves, Flowers, and Fruit, in which again there is Seed, by this means multiplying the Plant, which when dead, revives again in the Posterity of the same Species; let every one consider with himself, whether he could expect such a constant Circulation and Series of Plants in Seeds, and again of Seeds in Plants, that has lasted so many Ages without any Variation; and all the Instruments necessary thereto, from mere Chance, and a confused Concourse of Atoms.

SECT. II. *Without Earth and Water no Plants will spring from their Seeds.*

LET an Infidel or Sceptick examine farther the Earth and the Rain-Water (of which when we treated about Water itself, we shewed that all Plants do mostly consist) after as many different Ways as he can possibly; and

and then let him see, whether he can with any reason prove from thence how it comes to pass, that when we sow the Seed of a fine and sweet smelling Flower, or of nourishing Corn, and another of a poisonous Plant in the same sort of Earth, each of 'em will produce a Plant according to its own Nature, differing so much in Figure, in Strength, and other Properties; and let him say, whether it does appear to him with any kind of Probability, that all this is done without Wisdom; and the rather, forasmuch as Earth and Water being excepted, Experience has shewn in so many Cases, as the Learned *Malpighi* observes, *de Sem. Veget.* p. 12. that neither Urine nor Lye, nor Spirit of Copperas, nor Chalk, nor Salt-petre, if in too great abundance, nor Antimony, nor burnt Hartshorn, nor many other things when mingled with Water, and the Seed soaked in such Water, or when water'd with the same after they spring up, can produce any Encrease or Growth thereof. Nor, according to the Observations of the said Author, can Seeds produce their usual Plants in simple Water only: They that would be fuller informed of this Matter, may consult that accurate Writer in the Place above quoted.

Now when so Understanding and Learned an Enquirer has made so many Experiments about Plants in vain; and consequently, since 'tis not so easy for any one to discover wherein consists those Properties that are requisite for producing Plants out of their Seeds, and yet we see that they are in a manner found alone in Matters so contemptible to the Vulgar, and trampled under foot as Water and Earth; let any one that does still doubt of the gracious Direction of the Great Preserver of the World, ask himself, whether he could bestow upon a simple Seed, or upon Water and Earth, a Figure or Form, by which the whole World may be preserv'd from Death: And in case he can't (as hitherto no Body ever had such a Faculty) whether he has not just cause, from all these things, to acknowledge a Wisdom far superior to his own, and to that of all Mankind; and at the same time too, a Goodness and Bountifulness that has bestowed upon all Creatures their Food and Support.

SECT. III. Every Seed has its Seed-Plant.

NOW they that would see how far the Knowledge of Men has attained, in respect to the Parts of which Plants consist, and the Use thereof in their Encrease and farther Oeconomy, may consult thereupon the Learned Writings of *Grew*, *Malpighi*, and in some Cases of *Leeuwenboek* also, and others; and one would think that towards the Conviction of an Atheist, there would be nothing more required than to refer him to the Observations of those Persons: At least, that which can't occur to him without great Astonishment is, that he will find in the Accounts they have given about Seeds, that having enquired into a vast Number thereof, they have discover'd and seen in every single Seed an involved Stamen of the future Plant, which by *Malpighi* is named *Planta Seminalis*, or the Seed-Plant.

SECT. IV. *The Seed-Root and Pluma in a Bean.*

To say something thereof, which every one may easily try; take some great dry Beans, and steep 'em 24 Hours in Water; then take them out and lay them in a place that is dry, but not cold, so long till, as the Gardeners term it, they begin to shoot out; Strip the Skin off of one of 'em, and you will find the Body of the Bean consist of two Parts, lying with their Planes against each other, and having a little white Stalk or Sprig by which they are joined together; for Instance *Tab. XVIII. Fig. 4. a a a*, and *a a a*, are the two Parts of the slit Bean; *d c* is the white Root-Sprig fasten'd to both the Sides, and which afterwards in the Earth becomes the Root of the Plant. Now let an unhappy Sceptick say, since this Root *d c*, must first grow and spring out before it can be nourished by the Earth, and be turned to a Root for the whole Plant, whether he can imagine that it comes to pass without any proposed Design, that in the Body of the Bean, and in both the Parts thereof, there is another Root placed, represented here by *b b b b*; which is carried on to the white little Point *c*, on each side with a Branch *d d*, and thereby furnishes this little Root-Sprig *d c*, *d c*, with Nutricious Juices, in order to communicate thereto the beginning of its Encrease, and the Power of becoming a Root, before it be able to draw any Nourishment out of the Earth.

From this little sprouting Root *d c* there proceeds to the other Side another little Body *e*, which being the Trunk or Stalk in Miniature, does consist of a very little Stalk and Leaves; upon which account it is called by Dr. *Grew*, the little *Pluma*, or Feather; and the said Sprout of the Root *d c*, and this little Feather *e*, do make together the Stamen of the following Plant.

SECT. V. *Each Plant has two Roots.*

So that almost every Plant (as Experience teaches us, that the same thing happens in almost all the known Seeds after the same manner) is thus furnish'd with two Roots; the first of which is that describ'd here by *b b* and *b b*, and which spreads itself thro' the Body of the Seed, being therefore call'd the *Seed-Root* feeding the little Root-Sprout *d c*, and the *Pluma e*, so long till the first of those is big enough to draw Nourishment to itself out of the Earth, and then it becomes the second and last Root, causing the *Pluma*, now become a larger Trunk, to grow up to a compleat Plant. From whence it is farther apparent, that the Matter of the Seed itself, or of the Bean by which the first *Seed-Root b b, b b*, is extended, performs almost the same therein (by making the Root-Sprout *d c* put forth at first) as the Earth does afterwards when it becomes a larger Earth-Root, that is, does feed and encrease the whole Plant.

This *Seed-Root b b, b b*, appears more plainly in large Beans, and in the Seeds of Lupins than in many others, according to the Observation of the said Dr. *Grew*. And in case one cuts a fresh cropt Bean into thin Slices crosswise, one may see in every such Slice the Course of the little *Seed-Roots* (represented here by little Points or Dots) quite to the end; (see *Tab. XVIII. Fig. 5.*) where *b b* shew the Dots through which the *Seed-Root* is cut across; and

and if you should cut off thin Skins lengthwise from the said Bean, you may see the little Branches of the said Root that were just before cut across. *Tab. XVIII. Fig. 6.* shews the said white Lupin, as it appeared to Dr. Grew, of which *c* is the *Pluma*, *b* the Root, *dd* the Pith, and *a a* the Branches of the Seed-Root. *Fig. 7.* is the Seed of a *Gourd*, where the said Gentleman says, that one need only split it in two, in order to see within it the said Seed-Roots clearly and accurately in all their Branches. In other Seeds, where these Roots are not quite so visible, either because they are of the same Colour with the rest of the Body, or for other Reasons, yet the Root-Sprout, or the Feathers, may be always seen plain enough. [*Vide Grew, Cap. I. of his Anatomy of Plants.*]

SECT. VI. *The Cavity in the Bean for the Pluma.*

ONE might here add other Particulars; as for Instance, that in *Fig. 4.* the little *Pluma e*, is the Origin of the future Trunk, or rather the Trunk itself in Miniature; for which reason those that know how very necessary it is to the Existence of the Plant, and who likewise observe the Tenderness thereof, must they not be convinced, that it was with some View and Design, that in each Part of the Bean there was form'd a small Cavity to place the said *Pluma*, and to preserve it from all Inconveniences, in such a manner, that the Beans may be handled, thrown together in Heaps, and tossed into Sacks, without the least prejudice to the said tender Trunk?

SECT. VII. *The Hole in the Skin of the Root-Sprout.*

BESIDES all this, we see in the great Seeds, such as Beans, even with the naked Eye (and in those that are smaller, with the Microscope) that the external Coat or surrounding Membrane is always pierced or bored through with a very little Hole, directly opposite to the Point of the Root-Sprout *e*; to the end, that when the Seed is sown, and begins to shoot forth, this Root-Sprout may not be hinder'd by the Thickness of the closed Bark or Skin, from growing out and spreading itself in the Earth; in order, as we have said before, to serve afterwards for an Earth-Root to the Plant. Infomuch, that even Nuts, and hard Peach-stones, have the like Orifice or Hole to make room for the putting forth of the said Root-Sprout.

SECT. VIII. *The Nutricious Juice or Sap changes its Way in the Seed.*

THOSE that desire to be informed of other Particulars, in which the Wisdom of the Creator does appear, may consult the aforesaid laudable Authors, concerning the Structure of the Seed itself, and learn thereby to acknowledge a higher Direction of Him that has adapted the Instruments of the Seed thereto; among which there is one that cannot be contemplated without Wonder, namely, that the Nutricious Juice, which proceeding first from the Matter of the Body of the Seed *a a a a*, *Fig. 4.* through the Seed-Root *b d*, causes the Root-Sprout *d c*, to fix itself below in the Ground; after which it changes its Course as soon as ever this Root becomes strong enough to draw its Nourish-

E e e ment

ment from the Earth; and then on the contrary, taking its way upwards, it causes the *Plume* to shoot forth, in order to become a Trunk.

SECT. IX. *The Seed-Leaves, and their Use.*

IT is remarkable, besides all this, that in most Seeds, when the Root is big enough to feed the Plant, these Seed-particles *aa*, *aa*, are carried upwards with the Trunk out of the Earth, after which they compose the *Seed-Leaves*, so called, because these first Leaves, in almost all Plants, have a different Figure from the subsequent Leaves of the said Plants. This is very visible in some Seeds, as, for Instance, in Cucumbers, in which the Seed itself, with its white Colour, does first appear above Ground; and afterwards, by little and little, becomes visibly yellow, and then is turned into green Seed-Leaves; the same are as many in Number, as the Parts of which each Seed consists.

We do not here dispute, whether the Use of these Leaves is to communicate a more proper Food to the *Plume*, or tender Trunk of the Plant, than the Root is capable to do at that time from the Earth, and to moisten the said Trunk with the Dew and Water of Rain, which they receive by conveying it along their little Stalks, and so hinder it from being too suddenly dried up by the warm Air; or whether these Seed-Leaves help to defend the tender Plant from other Inconveniences, after the same manner as we see, in those Grains that have no Seed-Leaves, the *Plume* encompass'd with a Membrane like a Sheath, probably for the same purpose; and of which also, we may observe two little Membranes in the great Bean, that have likewise no Seed-Bladders. At least Dr. Grew observes, that in Seeds, the Parts of which springing out of the Earth are turned into Seed-Leaves, none of these Membranous Sheaths are to be found. We shall not determine any thing particularly in all these Matters; but that these Seed-Leaves are absolutely necessary in preserving and nourishing of the Trunk, and for the encrease of the Plant, is plain enough from the Experiments that the learned *Malphigi* has made concerning them, from whence he finally draws this Conclusion; *The Effects and Uses of these Seed-Leaves are so necessary, that if they be pulled off and separated from the Plant, it won't grow; and if it should any way increase, it won't be compleat, but remain always defective.* [See his *Treatise de Sem. Veget.* p. 16. of the London Edition.] Every every one may likewise make the same Observation.

SECT. X. *Conclusions from the foregoing Observations.*

DEPLORABLE Atheists, who in order to quiet in some Measure their uneasy Consciences, (which is terrify'd always, and in all Places where it expects to find a GOD,) and to harden it against its perpetual Pangs, are forced to ascribe all these admirable Properties, that display themselves so multifariously in the Body, and in the Operations of a little Seed, to Causes that have no Knowledge, and which when they produced such Seeds, were Strangers to what they did, and even to their own selves too. Now if any of those Atheists had been able to have produced any thing of the like Nature, tho' incomparably less perfect, and could have form'd a Seed from whence the very

smallest

Smallest Leaf of Grass might spring, would he not think that every one who should maintain that there was no Skill nor Judgment necessary thereto, would do him great Injustice? And in case a Seed or an Acorn were shewn to any Man who had never seen a Tree, and who having set the same in the Earth, should observe a whole Oak growing out of it, would he not, tho' never so much conceited of his own Wisdom; I say, would he not look upon it as a most amazing Phenomenon, especially when he found that so many hundred Acorns were yearly brought forth thereby? But an unhappy Atheist must judge quite otherwise in this Matter, and maintain a Notion, contrary to that of all Men, with what Satisfaction to his own Conscience will be best known to himself, when he rightly considers the Matter with himself, and discovers how little Reason or Ground there is to conclude, that each Seed contains the *Stamen* of the future Plant, and even of the greatest Trees, (as far as can be observ'd) in all their Parts folded, or rolled up like a Clew of Thread; and that all this is purely accidental. Let him once more examine himself, and consider whether, if there were nothing but Chance and ignorant Causes in the World to produce such Effects, he could satisfy himself in believing, that all these Wonders could ever happen, not to say constantly and regularly, in the vegetable Kingdom, and that one Tree could ever have been produced.

SECT. XI. *Considerations on the Texts in John xij. 24. 1 Cor. xv. 36. vij. 8. and Gen. ij. 4, 5, 6. with Observations on the last of 'em.*

Now since it is an experienced Truth with all Enquirers, that the Seeds of almost all Plants do not remain nor perish in the Earth; but that its Parts spring out of the Earth under the Figure of Seed-Leaves; the Grains of Corn and Beans being the only ones observ'd by Dr. Grew, that continue in the Ground, and produce no Seed-Leaves; the Words which we find spoken by the Son of GOD in *John xii. 24.* ought to have a particular Emphasis; *Verily, verily, I say unto you, except a Corn of Wheat fall into the Ground, and die, it abideth alone; but if it die, it bringeth forth much Fruit.* In which, agreeably to his infinite Knowledge, he is pleas'd to single out from among so many thousands of Seeds in which the contrary obtains, the only one almost which dies in the Earth; and which therefore was the only proper Similitude, and could only be accommodated to that Purpose, for which he intended to use it.

I know very well, that the Expressions here used, of consuming and dying, will shock some Naturalists, because there likewise proceeds from the same Grain of Wheat, both a Root and Stalk. But that however, there is nothing spoken herein, besides that which we can thus discover, will sufficiently appear by what has been writ by those who have carefully consider'd the same. Let us hear what Dr. Grew says of it in his *Anatomy of Plants*, Ch. I. where treating of Seed, and how it shoots up out of the Earth, he uses the following Words: *This does not come to pass in all kind of Seeds; for there are some which rot in the Earth, as Corn for Instance, which is different from most Seed, &c.* And lest we should think that the same thing happens in many Seeds, he adds a little lower: *But all Seeds, excepting these two (meaning Corn and great Beans) grow mostly after the same manner, so far as I could observe; they do not rot in the*

Ground (as he had said just before of Corn and Beans) *on the contrary, they come out at the same time as the Pluma; and the Seed-leaves are in most Plants the two parts of the Seed, &c.* And to the end that none should imagine that this Position is not sufficiently verify'd by Experience, let them consult *Malpighius*, so famed for his Accuracy, *de Sem. Veget.* p. 9. *Edit. Lovel.* where in his Enquiry into the Changes which a Grain of Wheat undergoes as it springs up, we find these words: *After the Eleventh Day, the Seed-leaf, which still hangs to the Plant, is shrivel'd, and in a manner corrupted.* Now that by this Term of *Seed-leaf* is meant the Grain itself in these Circumstances, appears by what follows a few Lines after: *In the mean while (that is, whilst it continues to grow) the Seed-leaf, or the Grain itself, pines and consumes away, and being become empty within, if one presses it, he will find nothing but a watry Matter in it,* which confirms what was said before; as also by what has been since observed in another kind of Grain, namely, *Millet-Milium, the Seed-leaf, which, as we have shewn, is the Grain, is shrivel'd or wither'd on the seventh Day, and being prest, yields a putrid and nasty Liquor.*

Thus we find the Holy Ghost expressing himself by the Pen of *St. Paul*, *1 Cor. xv. 36. That which thou sowest, is not quickned, except it die.* And to the end that the Modern Philosophers should not have it in their Power to object against this from their Experiments, that no Seed (excepting a few, and as far as is yet known, only the two above-mentioned sorts of Grain, and some Beans) do die in the Earth; the same Inspirer of that Sacred Writer, is pleas'd to go on thus, *Ver. 37, and 38. And that which thou sowest, thou sowest not that Body that shall be, but bare Grain, it may chance of Wheat, or of some other Grain: But God giveth it a Body as it hath pleased him, and to every Seed his own Body.*

SECT. XII. Concerning the Expansion of the Seed-Plant; with an Experiment of *Mr. Dodart* thereupon.

THEY that will be pleas'd to consider what we have said before relating to Beans, and particularly concerning the little *Pluma* with its Root, or otherwise the Seed-Plant before it shoots out in the Earth; and they that will farther take the Pains to read what those great Philosophers of latter Ages, such as *Malpighi*, *Grew* and *Leeuwenhoek* have writ about it; or rather those who, after their Example, have consider'd it all with a good Microscope, will know, that not only in all Beans, but also in all other Seeds that have been yet examined, there is such a little Seed-Plant to be found, in which all the Parts of the Plant that are to proceed from it, are involved or rolled up as it were like a Clew of Thread; which being afterwards filled and expanded by Nutricious Juices, becomes an entire and compleat Plant, whether it be a Tree, a Shrub, or a Flower.

To give some farther light into the Structure of such a rolled up Seed-Plant, and upon Account of the Wonderfulness thereof, I have transferr'd one of 'em from the *Memoirs of the French Academy* for the Year 1700. p. 187, and 188. to *Tab. XVIII. Fig. 8.*

In the said Memoirs Mr. Dodart says, that above 20 Years ago he had communicated to the Academy such a Seed-Plant, as it appeared in the above-mentioned Figure, when it was scarce come out of the Earth, and was only one Line, or the 12th part of an Inch long. He adds, that having viewed this little Ear of Corn with a Convex-Glass, the Focus of which was half an Inch, they could discover all the Seeds in it, and the Stalk or Trunk itself among those little Seeds, of the height of a Line and a half; they could likewise distinguish therein the Knots of the Straw; but all had a very different Proportion from what we see in a full grown Wheaten Plant. The Leaves, which do scarce otherwise make the sixth Part of the height of the Plant when compleat, were now above 18 times longer than it; the little Ear made about a third Part of the entire height, whereas, when the Plant is perfect, it hardly comes up to the 48th Part; the little Body of it was about three times as long as thick, tho' when full grown, the Height is incomparably greater, with respect to the Thickness; the little Tubes that compose the Straw or Stalk with their different Knots, appear to be thrust within each other, like the Pieces or Parts of a Telescope when a Man puts it into his Pocket. The Seeds were round, like perfect little Pearls, and half transparent: To form a more compleat Notion of them, you must suppose in the said Fig. 8. that A is a part of the Root from which this little Plant is separated; BCDE is the Tube of the Straw, of which B is the first Joynt between two Knots, C the second, D the third, E the fourth. Each of these Tubes, of which the whole Straw was composed, bore a Leaf, which is stripp'd off, to the end, that the Ear that would have been hid by those Leaves, might more plainly appear. F is the last Leaf, which leaves the Ear sufficiently naked. Finally, G is the little Ear, having already attained its compleat Figure in the middle of the little Sprout.

Now can any one observe this whole Contexture of the future Plant, in so small a Body, without amazement; and pretend to ascribe the same to Chance or Ignorant Causes?

The Gentlemen of the French Academy having made use of some Microscopes that magnified the Object much more than the above-mention'd, have observ'd in much smaller Seed-Plants than the aforesaid Ear of Corn, how the Parts of the future Plant were adjust'd together, which in shooting forth, extricated themselves from each other.

SECT. XIII. *Whether the Seed-Plants contain all the following ones.*

SEVERAL famous Men have gone so far in this Matter, that by seeing in each Seed its future Plant, some of 'em have maintained, and others, to use a softer Word, have conjectured [See Mr. Dodart's Memoir in the Transactions of the French Academy, 1701. p. 315.] that it was not improbable, that this Seed contained in its little Seed-Plant another Seed with another Seed-Plant, and so continually forwards; from whence then this Consequence must be deduced, that every Seed, how small soever it is, does actually contain the Seed-Plants, and their following Seeds, of as many Trees, for Instance, as might be produced from this one Seed to the end of the World;

World; and consequently, that all Kinds of Plants whatever, of the same Sort that there were to be produced in all the following Ages, were already actually formed in the first Seed that was created; by which they understand, that tho' the Imagination of Men cannot possibly represent to itself such an unconceivable Smallness and Number, yet the Incomprehensibleness of the Works of an infinite Creator, may be thereby set in a clearer Light, to the Reproach of them that deny him; *since* (as Mr. Dodart says in the aforementioned place, and which is also the plain Truth) *those that are accustomed to exercise themselves in Natural and Mathematical Sciences know, that they can seldom go far without meeting something infinite; just as if the Author of Nature, and of all Truth, had been pleased to fix the Seal of his chief Property upon all things.*

I leave these Opinions, which do not seem strange to several great Men, to their own Weight: But forasmuch as the said Mr. Dodart is pleased to bestow upon them the Title of *Conjectures*, as they really are; and since we endeavour, as much as is possible, to abstain from all Uncertainties, tho' never so probable, because there are Experimental Truths in abundance, which prove a God, and a Divinity of his Word, we shall not lay any farther stress upon this Hypothesis.

SECT. XIV. *Transition to the Roots and Trunks of Plants.*

WHAT we have now said about Seeds, seems to be abundantly sufficient to bring any one that has hitherto denied a Divine and Omnipresent Power, by which the Operations of all things are directed, to more reasonable Thoughts: But to shew how this Providence proceeds in all things, we should add something concerning the Roots within the Earth, and the Bodies or Trunks of Plants as they grow out of it. Now, how the Nutricious Juices are drawn or insinuated into the first from the Earth, and how by rising or circulating therein, they cause the Trunk to grow out of the same, we shall not here relate; forasmuch as that which has been said of it, is not founded upon sufficient Certainty, and all the Experiments that have occur'd to me, in order to prove the same, are still but too defective. They that desire to see any farther Account thereof, may consult the learned Opinions of *Grew*, *Malpighi*, and others; they that will only take the Pains to follow the Methods of those and other Enquirers, and view the things with their own Eyes thro' a Microscope, when they see a Tree or a Plant grow, and after that, consider the Structure of the Roots and Trunks, will never be able to persuade themselves that these Bodies have acquired their Form by meer Chance.

SECT. XV. *The Structure of the Root and its Parts.*

NOTWITHSTANDING the many different Conjunctions and Dispositions that these Parts which compose the Root have among themselves, yet in almost all those that have been examined, we find the following Analogy and Agreements, according as Dr. *Grew* has described them; namely:

I. The external Part of the Root is a Membranous Matter or Bark, consisting partly of a great Number of little Bladders like a Sponge, or rather like those Bladders which we see lying upon one another when we blow with a Pipe in Soapy Water; and partly of a Ligneous Matter or Fibres, that are so many little Tubes. The first Kind are visible through a Microscope; and the last are seen in some Roots, such as *Scorfonera*, and others, from the Experiments quoted by the said Dr. Grew, in the 2d Chapter of his *Compar. Anatom. Radic.*

II. The second Part, which composes the Root, and lies under the utmost Skin of all, is the Bark (*Liber.*) and this likewise consists of two Kinds of Bodies, the first of which is also a Collection of roundish Bladders, which, being dried, shrink in like a Sponge, but when steep'd in Water, swell out again. Among these little Bladders there are mingled several Vessels that convey the Sap, of which some contain in themselves a watry Humour, some a milky, and others of other Kinds; and they represent very different Forms, as they are disposed among each other.

III. The third Body that we meet with in the Bark, in the Roots, does likewise consist partly of the same Bladders, that are interwoven with those of the Bark, and those of the Skin; and of Tubes or Vessels that compose the Woody Part of the Root, and some of 'em contain Sap, and others only meer Air. These are likewise disposed after various manners, in different Roots.

IV. The inmost Part of the Root is the Marrow or Pith, which is found in some, but not in others. This likewise consists of little Bladders, and of the same kind of Body as we have described before in the Bark, and in the Woody Part of the Root: 'Tis often only a Vesfical Matter, and sometimes 'tis mingled with Woody Fibres, or with the little Tubes that convey the Sap and Air.

SECT. XVI. *These Dispositions represented in the Pepper-Root.*

THE Dispositions of these Parts do sufficiently appear in many Roots to the naked Eye, if they be cut across; but much plainer thro' a good Microscope; and we find 'em very accurately delineated both ways, by the said Dr. Grew.

I shall produce one here (*Tab. XIX. Fig. 1.*) in which, thro' a Microscope, part of a little Slice of the Pepper-Root appears, after the following manner: The outmost little Bladders A A, represent the Skin and its external Membrane; from thence to B B in the Bark, in which the Vessels that carry the Sap may be seen between B and L, representing inwardly a broader, and outwardly a narrower and more acute Composition: Between B and G we may observe several Kinds of Orifices of the Air-Tubes; and between G and E, another little Circle of other Vessels that carry Sap, in which from E to K is the Pith; the little Bladders in the Skin in the Bark, between the Sap-tubes thereof, and between the Air-Vessels too, and lastly in the Pith, are all of 'em, according to their different Sizes, visible enough.

SECT. XVII. *The Structure of the Trunk in an Alb-Tree.*

THE Trunks of Trees and Plants do consist of much the same Parts as the Knots, namely, of Vessical Globules, and various Tubes for conveying Sap and Air. Thus it has been observed by *Malpighi* and *Grew*, but however in a different Disposition and Proportion in respect to each other than in the Roots, and in several Plants with a very great Diversity, as to Size, Number, Place, &c. as may be seen in the said *Grew's Comparative Anatomy of the Trunks*, in many Instances, but not without Astonishment.

One Example we have produced from him here in *Tab. XIX. Fig. 2.* in an *Alb-Tree*, the fourth Part of the Trunk whereof is represented as cut across: *A B C D* is the Bark, of which *A B* is the outmost Skin, and *A H B* the Sap or ligneous Tubes ranged by one another in circular Dispositions next to the extreamest Skin; *I I* is the vessical Matter of the Bark, which below at *D* and *C*, has another kind of Sap-vessels, disposed in an arched or curved Order; *D C F E* is the Wood; *D Q L K*, *K L M N*, and *M N F E*, are the fourth part of three circular Superficies, each composing a great Tube from Top to Bottom, in such manner, that one of 'em grows every Year about the Tree; the real Wood is *S S S*; between *S* and *T* are the round Orifices of the Air-vessels, which are dispersed thro' the whole Wood, being larger in the inmost Part of the Circles *K L*, *M N*, *E F*, and lesser in the outmost; *E F G* is the Pith; *e e* the Bladders thereof; and *O o O o* are the *Insertions*, in which the vessical Textures of the Pith and Bark have a Communication with each other.

Hitherto these abovemention'd Naturalists have only discover'd a vessical Structure, and ascending Sap and Air Tubes; but *Leeuwenhoek* has likewise discover'd Vessels therein that run horizontally; and whereas the Figures of *Malpighi* and *Grew* do represent in general the Trunk and Root, and the Parts and Vessels of which, according to their Remarks, the same are compos'd; we may yet farther understand the Kinds of those Vessels as they have been observed with great Accuracy by the said *Leeuwenhoek*, and drawn by him from the Life.

SECT. XVIII. *The Trunks grow upwards, and the Roots downwards.*

Now if ever there occur'd in Nature a surprising Phenomenon capable of obliging the most obdurate Atheist to acknowledge, that in the Growth of Plants a wonderful Wisdom, Power and Goodness has had its own Ends in view, and has carried 'em on even contrary to the Imagination and Opinion of Men, 'tis certain the same is here displayed most evidently, and after such a manner as has hitherto been inscrutable even to the greatest Philosophers: The Wonder which we are ushering in with so much Pomp, and upon which such famous Naturalists as the Gentlemen of the *Royal Academy of France* do likewise bestow the name of *Wonder*, in their *Histories for the Year 1700*, and *1702*, is that Law to which we see so many Trees and Plants incessantly subservient: According to which the Roots of all Seeds are for ever found to grow downwards, and the Trunks thereof to grow upwards.

SECT. XIX, XX, XXI. Three Experiments made upon Beans, Acorns, and other Trees.

To give an Idea of what we have just now said very briefly; It is known, that in all Seeds there is not only a little beginning of a future Plant and Root, as may appear from the Beans, &c. but we likewise find, that the *Pluma* and Root-sprout of which we have treated above, have a determinate Place in all Seeds, out of which they shoot at first according to a determinate Course; but when they proceed, we always see that the Trunk ascends, and the Root descends into the Earth. They that desire to make a Tryal of it, may imitate that of Mr. *Dodart*, a Member of the *French Academy*, with very little Pains and Trouble; I my self have done it with several Beans, and to my great surprize, found it not to fail in any: 'Tis thus, if you split a Bean (*Tab. XVIII. Fig. 9.*) and separate two Lobes or Pieces of which it is composed, from each other, having first steep'd the said Bean 24 Hours in Water, and then dried it as long after, till it begins to shoot out as at 2, which will be the Root, you will see at 1 the *Pluma*, which is to be the Trunk lying in a hollow Place on one side; and in the other at 3, another little Cavity, in which the *Pluma* is likewise preserved: If then you take another of these Sprouting Beans, and Plant it as at A, so that the Root 2 extends it self downwards, it won't seem strange to any one that the Root-Stalk 2 (*vide B*) shoots downwards, and the little Trunk 1 upwards, forasmuch as the Situation of both of 'em do naturally tend thereto. But it will be very surprizing, when one takes the Bean C, and lays it upon its Side flat in the Earth, that the Root 2, and the Trunk 1, do not grow horizontally, which must have come to pass, if they had continued the preceeding Course, as the Bean seemed to determine it; instead of which we discover that both the Root 2, and the Trunk 1, make a Bow or a crooked Line, in order to proceed downwards and upwards: But to come to the utmost; can a Man see without Astonishment, that when he plants the Bean inverted, that is to say, with the Root upwards, and the Trunk downwards, yet the Trunk 1 winds itself about the Root upwards; and in like manner the Root 2 making a Semi-circle about the Trunk or Plume, takes its Course downwards. Now that these Figures may not appear somewhat improper, it is to be observed, that the little Trunks 1, 1, 1, at B, C, D, are drawn here before they were so old, that they could properly make their Appearance in the Air. See the *Memoirs of the French Academy* 1700. p. 18. Now that this does not only happen in Beans, is shewn by the said Mr. *Dodart*, in the *History of the French Academy*, 1702. p. 62. That Gentleman found in the Month of *December*, some Acorns lying in a heap upon a moist Place where the Ground was firm and compact, as in a beaten Path: Many of these Acorns had shot their Root in the Air without being in the Earth, and their little Roots came all of 'em out of the Point or Top of each Acorn, having the length of from 4 to 18 Lines, or 12 Parts of an Inch; and that which was wonderful, was that every one of these Roots bent themselves the shortest way towards the Earth, as if they all sought for

it. This was therefore the more strange, because he did not observe any of the Acorns, whose Points tended downwards, so as that if they had grown streight out, they could have reach'd the Earth; but on the contrary, he found one Acorn among 'em, the Point of which grew upwards, and in that he saw that the Root shot streight up about an Inch in length, but that it afterwards changed its Course, and as it grew, turned downwards to the Earth.

This then gave him a handle to make the following Experiment: He took six of those Acorns, and set 'em in a Flower-pot, after the manner as you may see in *Tab. XVIII. Fig. 10.* at A, that is with the Point streight upwards, so that the Roots that were to spring from 'em, seem'd not capable of growing any other way than upwards; he cover'd 'em with Earth of about two Fingers thick, and let 'em remain in the Pot the space of two Months, in which time they had shot out; and the Root having now acquired some length, made close to the Acorn an Inflection and Turn; and so in the rest of the Acorns, they grew down again, seeking as 'twere a depth of Earth, just in the same manner as at B: And now the Consequence certainly seems to be, that all these Roots having once taken this Course of growing backwards from the Point to the Tail, they would persist in it, and pursue their Course again right forwards; for which reason he took these Acorns and inverted 'em again, pressing the Earth down quite round 'em, to the end that it might touch every Part; so that they stood as at C, with their Root now turned upwards, which before at B tended downwards. In this Condition he left 'em two Months more, and the Event was, that having uncover'd them, he found that there was nothing less than their growing upwards, but that each of 'em had made a second and new Inflection or Elbow, as at D; in order to make their Roots, as it were in spite of all these Obstacles, sink down deeper into the Earth, where they must be if they would perform any Service.

The said Mr. *Dodart* relates a great many of the like Accidents with respect to Trunks, as he had done before concerning the Roots of Acorns; viz. That finding some Trunks of young Pine-Trees, thrown down to the Ground by a Storm, at a place call'd *Chaville*, some lying upon a greater Steep or Slope, others upon a lesser, as in *Tab. XVIII. Fig. 11.* of which all the extream Parts *ad, bf, cg*, grew streight and perpendicularly upwards; insomuch, that those that fell upon a greater Obliquity, as here at *E cg*, in order to ascend directly, were forced to make a much more acute Angle than the uppermost *D bf*, and *C ad*; which lay in Places, the Declivity of which was not so great: The like we may observe in many Branches of Trees, when they are hinder'd by any Violence from growing upwards; so that likewise Weeds, that spring out of the sides of perpendicular Walls, after running a little horizontally, extend their Trunks upwards again; and even when some of 'em are not stiff enough to bear their own Weight horizontally, insomuch, that they are thereby pressed downwards, we see that when the Trunk becomes stronger, they will make a little Inflexion, and then

grow

grow upwards. The first Instance thereof appears in *Tab. XVIII. Fig. 12.* at A, and the second at B; of this I observed not long since a wonderful Example in an Elder-Tree, growing out of the little Crack of a Wall.

SECT. XXI. *Convictions from the foregoing Observations.*

AFTER having consider'd this whole Matter, and particularly what has been said about *Beans* and *Acorns*, who can conceive the Reasons thereof! And if we do not ascribe it to an adorable Providence, which executes its great and wise Ends by means as yet unknown to Men, to the Confusion of its Enemies; then let any Body furnish us experimentally with a true Cause that may be sufficient for this Purpose; and shew us what Mechanical Operations and Laws are known to him in Nature, from whence we may plainly deduce this Phenomenon in all its Circumstances.

The Gentleman who made these Experiments, and so carefully observed all these things, was not ashamed to record the Weakness of his Understanding, and the Insufficiency of his Argumentations, immediately after the Relation thereof, even in the *Memoirs of the Royal French Academy*. I shall not here relate all the Reasons that are there collected, to shew the Nothingness of all the Hypotheses hitherto laid down; any Body that has a mind may see them there himself. But I cannot here forbear to take notice of the noble Acknowledgment of an Adorable GOD, which the worthy Author subjoins upon this Occasion; and which such great Philosophers, as are the Members of that Academy, have permitted to be so emphatically expressed: For Mr. *Dodart* having in the said *Memoirs* for the Year 1700. p. 72. suggested all that is yet unknown, and that seemed requisite in order to trace in some manner the true Cause of this Effect, concludes his Discourse in these Words: *I know nothing of all this, and chuse rather to wonder at a certain continual and amazing Phenomenon, than to flatter my self with imagining that I know something of that, of which I know nothing at all. I confess I would very willingly discover the Cause thereof, but my Ignorance will not suffer me to enjoy a Pleasure which would overpay the loss I suffer by not understanding the Natural Cause of so wonderful an Appearance; for this Darkness and Ignorance in which I find my self, makes me see, and even makes me palpably sensible of a Supreme Cause, whose Wisdom and Power infinitely surpasses not only my Thoughts and Conjectures, but also those of all Men of the quickest Apprehension and Judgment that ever were or ever shall be.*

Now let the Atheist tell us, whether he ever durst maintain, upon seeing a ploughed Land full of Corn, by which his own Life, and the Lives of so many more must be maintain'd, that the Plowing, Sowing, and Preparation of that Ground, and the Production of the Corn from thence, was all performed by mere Chance, without any Concurrence of the wise Husbandman; and yet can he imagine that he argues rightly, when he asserts, that what we see happening to these Seeds in their Growth (and without which all the Pains and Charges that have been bestowed upon the Land would be fruitless) can be ascrib'd to a Cause that neither knows itself nor any of its Operations? For unless Providence had been pleased to take so much

Care, that the Roots of all Seeds should tend downwards to the Earth, and the Trunks or Bodies upwards, tho' the Seeds themselves were thrown into the Earth, either horizontally or inverted, it won't be necessary to prove, that every thing that lives by Sowing being deprived of its Nourishment, would soon perish: Since, by far the most Kinds of Grain, and all other Seeds that are strewed and sown either by the Hand, or by Wind, as most are, it is hardly credible, that one of them should fall in such a Posture, as to shoot forth its Root directly downward, and its Trunk upward, and yet this is requisite, if they grow as they should.

SECT. XXII. *The Knots and Buds of Plants, and Convictions from thence.*

WE don't think it necessary to transfer hither all the Observations which the Naturalists have made upon the Texture of Plants by the help of their Microscopes, since we don't pretend to give an entire History of *Botany*; wherefore those that desire to contemplate the numberless Wonders that occur therein, and which do uncontestedly demonstrate the Power of GOD to such as are any way reasonable, may be pleased to consult what Messieurs *Malpighi*, *Grew*, *Leeuwenhoek* and others have writ concerning the same; we shall only say a word or two briefly about them: Now they that have seen before the Texture of the Roots and Trunks of Plants, if they should take a yearly Sprig of a Tree into their Hand, can they think it happens by Chance, that it is furnished round about with Knots or Buds so exactly placed at a due Distance from each other, which Knots are the Source or Beginning of Fruits or other Branches! But particularly, can any Body see without Astonishment, that each of these little Knots does regularly spring from the inmost Part of the Branch, and that the Structure of the ligneous Fibres and little Bladders of the Branch, are ranged so nicely in this Form, that upon the putting out of the Branch, the Knot or Bud that is composed of the same Matter with it, may likewise shoot out?

Besides all this, one of these little Buds only may seem sufficient to make any one who seeks for a GOD, to find him therein; let him but contemplate in the 74th Figure of *Malpighi*, *Cap. de Gemmis* (and which is transferr'd hither in *Tab. XIX. Fig. 3.*) the Structure of an Oak-Knot, where are represented at A some of the little Bladders of the Pith of the Twig, which you may observe to be surrounded with ligneous Fibres at B; C is the Bark, the Fibres of which do further compose the Leaves D of the Knot. So that all Knots consist of the little small Sprig A, with its Bark, ligneous Fibres and Bladders; and the said Sprig is preserved by little Leaves lying upon one another like Scales, and encompassing it round about.

In the Bladders of some of these Knots (for almost all of 'em differ from each other) are little Nipples or Globules, containing in them a terebinthinous or glutinous Matter.

These Knot-Leaves, if we trace their Growth, do appear in many Plants gradually longer, and in time are changed, shooting out into Stalks of the following Leaves, which cloath the Branch proceeding from thence. How wonderfully this happens in several Plants, may be seen in *Malpighi's Anatomy of Plants*, p. 26, &c.

Where-

TAB. XVIII.

Fig. 2.

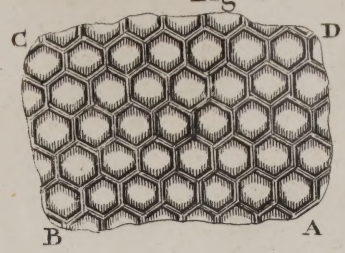


Fig. 3.

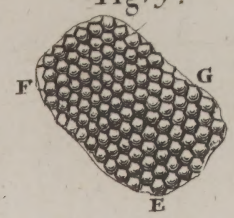


Fig. 1.



Fig. 6.

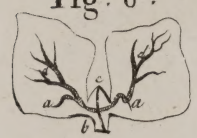


Fig. 5.



Fig. 4.

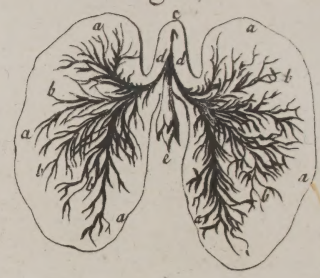


Fig. 7.



Fig. 9.



Fig. 10.



Fig. 11.

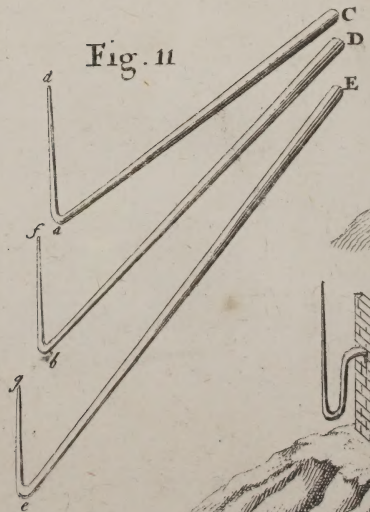


Fig. 12.

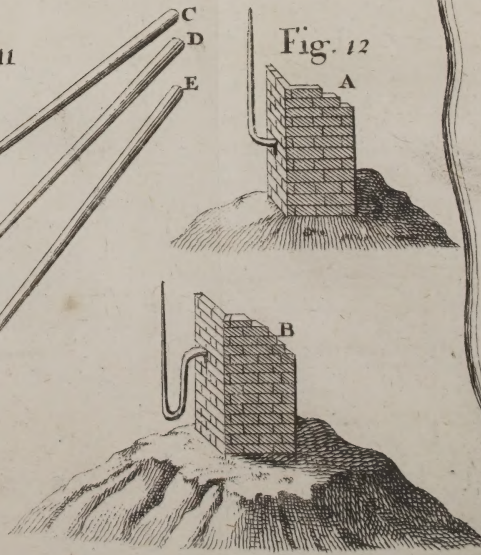
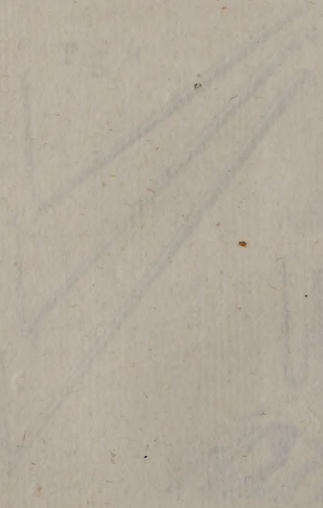
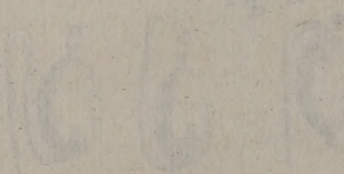
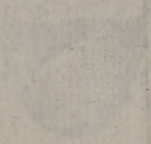
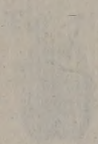
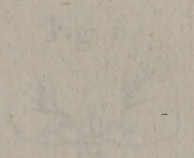
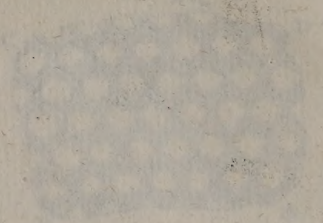
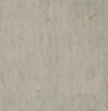
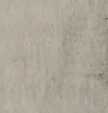
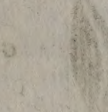
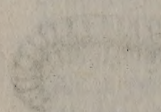
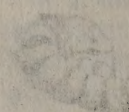
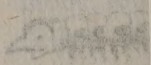
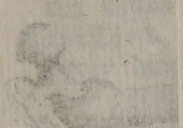


Fig. 8.





Wherefore the said Gentleman having observed all this with an unwearied Diligence, justly concludes, that the Sprout of the Knot does already comprehend the future Branch in Miniature. This will appear so much the more plain, if one reads the fifth Continuation of Mr. *Leewwenhoek*, who says, that in the Bud of a Currant-tree, even in Winter, he could discover not only the Ligneous Part, but likewise the Berries themselves, appearing like small Grapes, and that the said Ligneous Part or Stalk shot out exactly at that place where the Bunches of Currants first appear. B C D, *Tab. XIX. Fig. 4.* are the two Bunches of Currants, and E F G the young Sprig or Branch, according as the said Mr. *Leewwenhoek* has describ'd them.

Now if any one can believe that this Stamen or Principle of a Plant, which discloses itself in these Buds, roll'd up in a Space so unspeakably small, and with so much Regularity, is to be ascribed to mere Chance, why does he not maintain the same of the finest Watch that was ever made?

SECT. XXIII. *The Structure of the Leaves, and their Usefulness.*

How the Leaves of the Branches proceed from those of the Knots, we have in some manner shewn above: They consist of the same Parts with the Trunk and Branches, and have Wood and Sap-Vessels of several Kinds: Thus the Sap in the *Tithymallus* and others, is white; in the *Chelidonia*, yellow; in others, of other Colours; and each of 'em have their Air-Vessels.

The Wood, or Air and Sap-Vessels being collected in the Stalks, spread themselves out in the Leaves like so many Branches of little Trees, and these compose the Ribs of the Leaves, which in some Plants are knit together Reticularly or Netwise: Between them are the little Bladders which make the Thickness of the Leaves; in the upper Superficies of some Leaves we find little Orifices, which proceed from internal hollow globular Bodies, and through which perhaps there exhales either a Vapour or liquid Matter; to which Matter proceeding from the Leaves of Trees, may perhaps be referr'd that which is said in the *Memoirs of the French Academy*, 1707. p. 62. at least *Malpighi* affirms, that these Cavities may be plainly seen in Chestnut, Poplar and Mulberry-Trees, when the Bladders that are in the Leaves are dried up. The XIXth Table represents in *Fig. 5.* how the large Rib A sends out little Branches B through the Leaf, which, with other Branches C, that proceed from them, make up those Reticular Interstices, which here in the Figure appear Blank, in which may be seen the hollow globular Bodies D, opening externally. In these white Interstices there are likewise little Bladders E, disposed orbicularly, and which often make such a Cavity as F, out of which there filtrates a kind of a glutinous Liquor. Now, whether all this happens by Chance and without any Wisdom in such a Number of Leaves in each Tree, together with the Changes in all of 'em so necessary to the well-being of each in particular, one may safely submit to the Judgment of any reasonable Person; the rather, since we see that these Leaves are so exceeding necessary to the Trees, that

when they are robb'd of the same too early by Caterpillars, or other Causes, they can bring no Fruit that Year to Perfection. Now, whether these Leaves do render the Sap and Juices of Trees and Plants more proper to fructify, or whether they contribute any otherwise to the well-being of the Plant, since they seem to extend their open Arms, as it were, towards Heaven, to receive the Dews and Rains thereof; and to derive them farther for other uses, we cannot yet determine; this at least is probable, that in many Leaves the little Stalks are contrived more or less gutterwise, so that the Dew and Rain falling upon the Leaves, may run along them, and be conveyed to the little Knots (which are often found in Trees, in those Parts where the Leaves spring out) in order to moisten the same, other Stalks are round, along which the Water can creep well enough from the Leaves to the Knot, but not in so great a Quantity: So that these Leaves seem at least to serve to supply each little Knot with Water. Will any Body pretend, that this likewise is to be ascribed to Chance?

We likewise see that the Juicy Fruits that are in danger of being dried up too soon by the Heat of the Sun, such as Mulberries, Strawberries and Currants, are furnished with Leaves larger than themselves, to the end, that they may be cover'd thereby; and that Apples and Pears, that are more solid, and require a stronger Influence of the Sun, have smaller Leaves, tho' their Trees are often bigger.

Besides all this, since the Leaves do shadow the Tree, and since we have shewn above in *Contemplation XIX.* that this is the Cause that the Air with its watry Parts, is continually driven towards it; we may likewise observe from hence, that the great and adorable Preserver of all things, has, by the means of Leaves, imparted to Trees such an Advantage, that tho' no Wind should move the Dew and moist Vapours of the Air, yet through the greater Coolness of the Shadow, the external warmer Air being condens'd and driven thitherwards, carries its watry Parts with it to the Trees, and continually moistens the same.

SECT. XXIV, XXV, and XXVI. *Several Experiments to shew the Perspiration of Leaves.*

I SHALL not here enquire whether with all this the Orifices likewise which *Malpighi* observed to be in the Leaves, may not perform the same Functions in Trees as the Pores of the Body do in Men, that is to say, to cause an invisible Perspiration: This the Perfumes and Scents which we find in the Air under many Trees, seems to render very probable: And the same is likewise corroborated by the Experiment of *Mr. de la Hire*, in the *Memoirs of the Royal French Academy*, 1703. p. 73. This Gentleman, in order to try whether Fountains could be produced by Rain only (according to the Opinion of *Mr. Marriote*) had a mind to try how much Water was necessary to the growth of a Plant; for which reason, upon the 30th of June, about Five in the Morning, he took two fresh pluck'd and solid Fig-leaves, and thrust their Stalks in a Bottle that had a narrow Neck, and which was filled with Water, so that the End of the Stalks might touch it; then he closed

closed the Mouth of the Bottle so carefully, that no Water could evaporate from thence but thro' the Stalks; having weighed the whole, he set it in a place where the Sun shined, and where the Wind did blow a little. The Fig-Leaves alone weighed 5 Drams and 48 Grains; at Eleven o' Clock he found that the whole was lighter by two Drams, on account of the Particles that were drawn out of these Leaves by the Air and the Sun; having likewise found in other Plants, of which he had made tryal, always a great Evaporation of Moisture. But he has not taken notice, whether the Water which at first weighed a Pound, was so much diminished, or whether the Leaves were so much dried up, or whether the loss happen'd partly to both; however, he proves from thence, that there was a sensible Perspiration thro' the Leaves: Which may likewise be concluded from the Experiments of Dr. Woodward, mention'd in the *Philos. Transf. Numb. 253*. So that it appears from hence (at least it seems so) that the Leaves, besides other Uses, do likewise serve for the Perspiration of Plants.

I should now have pass'd on to something else, did I not think that (in order to give some Light to the so obscure Structure and Oeconomy of Plants, and thereby render the adorable Wisdom of the Creator, the clearer in so many of 'em, and to understand the Nature of 'em with greater Certainty) the following Experiments might perhaps be of some use.

I find among my Notes for the Year 1696, that upon the 21st of January, we cut a little piece of a *Radish*, and another from the middle Rib of a *Colwort-Leaf*, and a third of a sowre *Oak-Apple*, and put each of 'em into a particular Glass, fastening 'em at the Bottom with a Brass Wire, and then fill'd the same with a strong Lye made with Water and Pot-ashes, filtrated thro' a Paper: then setting them all under the Receiver of the Air-Pump, we observed, that upon taking away the Pressure of the Ambient Air, a great Quantity of Air ascended from each of them, particularly from the sowre *Oak-Apple*, which produced a perfect Froth upon the Superficies of the Lye (we shall not here inquire whether this last might not be increased by the Fermentation of the Acids of the Apple with the Salts of the Lye) and every time we exhausted the Air, the same Effect followed. The reason why we made use of Lye rather than Water, was, that it might not be objected that the Air, which is oftentimes found in Water, might contribute something thereto; tho' even in Water also, and before that the Air is boiled out of it, the thing appears so plain, that no Body, who is not too scrupulous, need make use of Lye.

On the 2d of June, 1696, we took two little pieces of the Branch of an Elm, and put 'em both into the Lye, and under the Receiver, one of which was placed with that End upwards that grew next the Trunk of the Tree, and t'other in a contrary Position; then exhausting the Air, we observ'd that a great many Air-bubbles ascended equally out of the Bark of each of 'em; but that out of the middle of the Wood, the Air flow'd as it were in an entire Stream, both at the under and upper End; and when we cut away a little of the Bark from the Ends, we observed the same, as also when we put in Wood without Bark, and Bark without Wood, the Air came out very strong-

ly from both. About a Week afterwards we took a single *Asparagus* that had been two Days out of the Earth, cut it to pieces, and observed a great deal of Air to come out of it, but nothing near so much as what came out of the Elm-Twig; most of the Air came likewise out of that End that stood upwards in the Earth: There appeared some little Bubbles at the other end, and some came also, but not many, out of the Sides of the *Asparagus*.

On the 7th of *June*, 1709. we tied a little piece of a Branch of a Morello-Tree to two Nails, and fasten'd 'em with a Thread to the Hook of the Receiver of the Air-Pump; so that being put into a Glass full of Water, it hung about three Fingers breadth under the Surface of it.

After that, we took a little piece of the Stalk of the Flower, called the *Imperial Crown*, and tied two Nails to it likewise, to make it subside in the Water; then drawing off the Air, we observ'd a whole stream of Air rising upwards out of both; from whence it appears, that the Stalks or Trunks of Plants do contain a great deal of Air in them, and what was before discover'd by the Microscope, is hereby confirmed.

To examine into this Matter a little more strictly in Leaves, we tied five Morello Leaves together by the Stalks, and then cut off about half of 'em, to the end, that the Tubes or Canals in their little Ribs being open'd, the Air might more easily be drawn out of them; then putting them into a Glass of Water, after the same manner as before, we could observe scarce any Air to come out of the Sides of the Leaves that had been open'd by cutting, but the Superficies or flat Parts of the Leaves were cover'd with clear Air-bubbles, insomuch that those Bubbles swelling bigger by our continuing to pump, the Leaves and the Nails to which they were fasten'd, rose up to the Top of the Water; but upon letting in some Air again, the little Bubbles disappeared as usual, and the Leaves subsided.

From hence likewise it seems to follow, that Leaves perspire very much, and that their Pores are more numerous than those of the Stalks or Trunks of Plants. There was likewise this remarkable Difference between the Leaves and Trunks, namely, that the Trunks did indeed emit whole Streams of Air from their open Ends, but that there were none, or very few, Air-bubbles externally upon the Bark: Whereas on the contrary, there seemed to be very little Air flowing from those Parts of the Leaves where they were cut, but a great many Bubbles upon their Superficies.

Perhaps by comparing all this together, there might be a Foundation for a probable Hypothesis, to shew the manner how the Sap is circulated in Plants, namely, by the Rarefaction of the Air in the Day-time, when 'tis warmed by the Sun, and by the Cessation thereof in the Cold of the Night; but this is not our Purpose here, and a greater Number and Series of Experiments would be requisite to confirm the same. Our view in mentioning these Matters, is, *First*, to shew that we ought not to doubt of what has been advanced concerning the Plants by those Gentlemen that have examined them so far with Microscopes: And, *Secondly*, to open a way whereby the Manner of Growing, and the Circulation of the Sap in Plants, may be traced after another manner than by the help of Microscopes; and thus by using different Methods

to discover these surprising Wonders of the Creator, a greater progress may be made for his Glory and Honour.

SECT. XXVII, and XXVIII. *The Structure of Flowers, with their Supporters, and without.*

IF we pass from the Leaves to the Flowers, which consist of the same Matter as all other Plants, *viz.* of Air and several Sap-Vessels, otherwise termed Wood-Vessels, and of a vessical Structure, besides which, we find that most Flowers proceed from a Bud or Knot (which the Florists call the *Calyx*) the Leaves or Parts of which do first cover the Flower contained therein, whilst it is yet unable to bear the Inconveniences of the Weather, and defend it from the same; and after that the Flower is blown, they keep up its Leaves, that they may not hang confusedly together, but regularly represent their Beauties to the Eyes of the Beholders. Let us contemplate a Carnation, for Instance, and see first how its green Bud secures the Leaves of the Flower, and then keeps together the little weak Stalks thereof, that it may nourish the Seed; and moreover, how it is indented at Top, in order to close the Flower the better while it is in Bud, and afterwards to spread out more largely, in order to support the Leaves more strongly. Let us observe the same in Roses, and a thousand other Flowers, all which are furnished with such a Calyx and Supporters proceeding out of it, some with one circular Leaf, as is the Carnation, others of more, as the *Roses*, others of little Leaves lying upon one another, like the Scales of Fishes, as the *Cyanos* or *Corn-Flower*; others after infinite other Manners, yet all serving for the same Use; so are the Artichoaks made of such Cups only, with Leaves lying upon one another.

Now since these things (all concurring to the same End in such an infinite number of Flowers) cannot be ascrib'd to mere Chance, to the end, that no Body may deduce the same from an ignorant Necessity flowing from the Structure of all Flowers, since this happens in almost all that stand in need of being preserved in the Bud, and of being supported when blown, we shall see, that in all Flowers, the Leaves of which are strong and powerful enough not to want such Supporters, such Cups or Leaves distinct from the Flowers are not to be found at all: Of this kind are white Lillies, all Tulips, and many sorts of other Bulbous or Onion Flowers, which are cover'd in the Bud with a thin green Leaf, and, when blown, support themselves by the Strength of their own Leaves only: Thus we see in Crocus or Saffron, which comes up in the Spring, and which having no *Calyx* or Bud sufficient to cover it, that it is provided with a white membranous Tegument, by which its Flower is preserved from the pernicious Effects of the Air whilst it is yet tender.

SECT. XXIX. *Some Particulars about Flowers.*

OF the Leaves of Flowers, and of their ravishing Agreements, as they affect the Sight and Smell of every Body, we shall not take any notice here, they being so well known; only it is to be observed, that as the Cup and Leaves surround and preserve the Flowers, so likewise the Flower-Leaves do secure the Heart or inmost Part thereof, and that many of 'em are cloathed

with a Down or Natural *Farina* about their Heart, in order to provide a softer and warmer Lodging for the little Sprout in the middle of 'em.

We shall likewise pass by all the wonderful Particulars that *Malpighi* and *Grew* have already noted in Flowers, such as their little Horns and little Hairs, their Magazines and Store-Houses of slimy and terebinthinous Matters, particularly the Places where a Sweet and Honey Liquor is separated and preserved in their Leaves. They that see this Liquid Matter gather'd by the Bees, and serving so many Purposes to Mankind, will at least learn thereby, that it is not without reason, that he who acknowledges a Glorious God for the Maker of all things, may, besides the Adorableness of his Wisdom, observe also from hence, the Greatness of his Bounty and Favour to us.

Nor shall we take upon us to describe in this Place the Parts of Flowers exclusive of their Buds and Leaves, so far as the same are not yet compleatly known to us; such as, for Instance, the Places in the Heart or Middle thereof, in which the Seed is formed, nor yet the little Threads, nor the stiff long Excrescences that bear other little Bodies, full of a certain fine Dust at the Top of 'em, such as Lillies and the like; the former of which the Botanists call *Stylus*, and the other *Stamina*.

SECT. XXX. *The little Threads, &c. and Convictions from thence.*

ONLY let us finally make this Remark, and ask, whether an Atheist seeing the Branches of a Vine so weak, that they can't possibly support themselves, does not believe, that it is with a wise Design, that they are furnished with those Threads by which the Joynts or Knots fasten and support themselves on every thing that sticks out? and, whether he does not observe a Design therein, especially, since those Threads, after having twisted themselves about any solid Matter, are yet unable to bear the weight of the Bunches hanging upon 'em, were it not that the Matter of which they are composed, was incomparably tougher than any thing else in the whole Vine.

Thus it is likewise with the Cucumbers, the Branches of which would easily be broken by the Wind, were they not strengthen'd by some other Threads and Supports. If there be not a wise End and Design in all this, how comes it that the *Ivy*, which grows never better than against a Wall, shoots out of its Side, as it were, little Roots or Sprouts, which having a glutinous Moisture in 'em, do thereby cleave to the said Walls, and so support such a great Apparatus of Leaves and Branches; which how wonderfully it comes to pass in the *Canada Vine*, has been described by Mr. *Malpighi*.

Now to convince an Infidel by some farther Instances, if it be possible, can Chance be the Cause of all things in Plants, each of which bears a Seed, from which exactly the same, and never any other Plant proceeds when sowed in a proper Ground; as for Example, a Vine never produces Figs, or any other Fruit besides its own Grapes.

Pears, Apples, Grapes, &c. ripen first nearest their Stalks; Figs, Melons, Peaches, Plumbs, Abricots, &c. farthest from their Stalks.

In Carnations, Jasmine, and others, the highest Flowers, or such as are most remote from the Root, come first to Perfection; in Lillies and Hyacinths, &c. the lowest in Raspberries, this happens indifferently.

The Trees of Apples, Pears, Peaches, Abricots, Cherries, &c. bear Fruit at two Years growth; but Grapes, Nuts, Raspberries are produced the first Year.

Thus in many Trees those Leaves that are farthest from the Root wither first in Autumn; but in Pease, Beans, Artichokes, and many others, yea even in Peach and Almond-Trees, we see the contrary.

In many Plants the Fruit proceeds from the same Part where the Blossom was, as is well known; but in the Small-Nut, Hazle, and Chestnut-Trees, and also in *Turkish* or *Indian* Corn, the Fruit comes where the Blossom never was.

Almost all Fruits are preceded by their Blossoms; but the Fig grows perfect without a Flower; and in Melons, Cucumbers, &c. the Fruit is seen before the Flower.

In Fruit-bearing Wood, the Fruit and Leaf are mostly together, but in Vines it is chiefly the contrary, where the Grapes and Leaves are on different Sides.

In some Trees the Branches are long, because their extream Parts are lengthen'd out, which is most usual; but in Vines, in Tulips, in Carnations, &c. the extream Part remains without shooting out farther, and the Lengthening is made by the growing of that which is below.

They that would see more of these Remarks, may meet with 'em in the Reflections upon Agriculture, of Mr. de la Quintenye, Ch. XVIII. and judge from thence, whether the All-wise GOD can shew more plainly, that his Power of directing all things according to his good Pleasure, is confined to no necessary Laws, than by making us see in Plants, that there is nothing in one part of 'em which he cannot produce in another, after a seeming contrary manner, to the same End and Purpose.

SECT. XXXI. *The Curse of the Earth.*

THEY that have observed the Frankness and Sincerity of this famous Florist, and Director of all the Royal Gardens in France, in several Expressions of the aforesaid Treatise, will not be surpris'd at the blunt Acknowledgment of his Ignorance in the following Words of the XVIth Chapter: *I cannot conceive how it comes to pass, that the Earth grows Weak and Lean, with respect to those Plants which are in some measure Strangers to it; as for Instance, Corn, Herbs and Trees; but yet seems to have preserved its whole Strength; nor does its Fruitfulness appear by any means to be diminished, with respect to its Production of Thorns and Thistles, and an infinite Number of other ill Weeds.* Every one who makes use of his Reason and Experience, as a Naturalist, and no otherwise, will doubtless be at a loss to assign the true Causes of this Fact: I speak here of the true Cause only, because it is not so difficult to advance an Hypothesis, and from thence to deduce a seeming Effect of Nature; and we all know that there are many such laid down, of which nevertheless

less none come up to the Truth. We shall not here dispute about the Natural Cause thereof; but only ask an Unbeliever, when he reads the Curse pronounced against the Earth by the Creator thereof, for the Sin of our first Parents; *Gen. iii. 17, 18, &c. Cursed is the Ground for thy sake; in sorrow shalt thou eat of it, all the Days of thy Life: Thorns also and Thistles shall it bring forth to thee; and thou shalt eat the Herbs of the Field.* Whether, tho' he did not allow all these Words to be Divine, he be not obliged to own, that the Contemplation of Nature would teach him the same thing: And that it is worthy of his most serious Reflection, that the Earth, without any Diminution of its Strength, is able of itself to produce Thorns and Thistles, and other useless Herbs in Abundance; but when it comes to bring forth all kind of Grain, and other Plants proper for Food, it becomes then Lean, and loses its Fertility. Now if he does not with us deduce this from the above-mention'd Curse, and yet will satisfy himself, and any other reasonable Person; it behoves him, *First*, to shew the Cause why this happens not only now, but has come to pass after the same manner in all Ages, and in all Places. *Secondly*, If he thinks he has discover'd the true Reasons thereof, it will lye upon him to prove likewise, that this will necessarily follow from the Structure of the Universe, and that it could not fall out otherwise, but that the Earth must needs produce Thorns and Thistles, and other Weeds, without impairing its Strength; and that just the contrary must happen, when it produces the things that are useful to Mankind.

SECT. XXXII, XXXIII. *Plants do not yield so much as they are able, and a Proof thereof shewn in Trees.*

MOSES adds farther in the said 3d Chap. of *Genesis*, v. 17. *in sorrow shalt thou eat of it [the Ground] all the Days of thy Life.* And in the 19th Verse,—*in the Sweat of thy Face shalt thou eat Bread.* But we have touched upon this already in *Contempl. XX*. However, we see in these Places such things foretold, which hitherto have been completely fulfilled; and whereof (unless the Cause be ascribed to the aforesaid Curse) the universal and necessary Consequence can never be proved by any Body; the rather, since this particular Curse denounced a second time against the Earth, on Account of the Murder of *Abel* by his Brother *Cain*, is still daily fulfilling in our Sight, *Gen. iv. v. 12. When thou tillest the Ground, it shall not henceforth yield unto thee her Strength.* Which may be inferr'd from the Structure of Trees and Plants, that seem to be made to yield incomparably more Fruit than we see them now do; and which, by what follows, shall be undeniably proved.

I acknowledge, that it has been formerly objected to me as something very obscure, (when GOD was pleased to say to Man; *Behold, I have given you every Herb bearing Seed, which is upon the face of all the Earth, and every Tree in which is the Fruit of a Tree yielding Seed; to you it shall be for Meat*) how it could be possible, and be made to agree with the Plants and Trees, that they should have furnished to all Mankind the necessary Support and Food, in case Sin had not come into the World, and Men had thereupon continued Immortal, according to the Structure we observed above in their Bodies, which

which represents a compleat *Perpetuum Mobile*, or a Machine of an everlasting Motion. For tho' it had pleased G O D to have taken them after a while from the Earth (into which, as having not been revealed to us, we shall not here enquire farther) yet it seems to be very probable, that the Earth would have been incomparably more Peopled than now, when so many are so suddenly snatch'd away by Death.

But that which seems perfectly to solve this Difficulty, and yet more to confirm the Curse of G O D, under which the Plants do likewise groan, is the Structure of Trees, by which it appears, that unless there was something to hinder their Natural Fruitfulness from being exerted, very few of 'em would be able to feed and sustain a far greater Number of Men and Beasts, than is now done by a great many, according to our present Experience : To speak more clearly of this Matter, we see a powerful Example of the wonderful Structure of Trees ; forasmuch, as if the Branches of a Vine, and of several other Trees, whether cut off or growing still to the Mother-Plant, when set in the Earth, will put forth both Roots and Branches ; as also, that the Roots of many such, as Plumb-Trees, and others, will oftentimes raise a whole Wood of new Plants round about the Tree which they feed ; from whence the Strength of a Tree increasing its Fruits by new Plants, does manifestly appear. But not to treat of all in particular here, it is well known ; 1. That each Branch of a Tree produces several Buds or Knots. 2. That each of these Buds has also the Power and Faculty of still producing another Branch, which will likewise have its Buds or Fruits. 3. These Buds must pass for so many Wonders with every one that rightly contemplates them ; forasmuch as each of 'em, if they be fitted thereto, will grow up to a large and perfect Tree, which again will yield thousands of other Buds and Fruits. The Modern Inoculation or Grafting of Trees, is a notable Instance thereof ; for in this Case, as it is well known, a little slice or bit of the Bark, in which there is a Bud contained, is thrust in between the Bark and Wood of another Tree, and so, if it grows, does commonly produce a perfect Tree : And to the end, that we may be ascertained that such a Tree does only proceed from the said Bud, and not from the Trunk of that into which it was grafted, we need only observe, that the whole Branch will be of the same kind with that Tree from whence the Bud was separated ; nor shall we perceive one only Fruit or Leaf upon it that was peculiar to the Trunk. Thus, if an *Abricot* be grafted upon a *Plumb*, a *Peach* upon a *Plumb* or *Abricot*, and a *Pear* upon a *Quince*, &c. there will only proceed an *Abricot* from the first, a *Peach* from the second, and a *Pear* from the third. Moreover, we are taught by the known Observations of Gardeners, that if the little Trunk of the Inoculated Bud be pluck'd off, and the Cavity that was made in the Bark remain unfilled up, the said Inoculation will not grow on, altho' the Tree should be strong enough. I will not now ask an Atheist, as one might justly do, whether any reasonable Man can imagine that the Structure of these Buds (each of which comprise the whole Tree in little, and which Tree is produced, and as it were rolled out by the increasing and nourishing Saps)

Saps) could be formed by Chance, and without a Wisdom which had in view the Growth of Trees, Branches and Fruits? And for the farther Conviction of an Infidel, and to prove from the foregoing Remarks about Buds only, that Trees are capable of producing vastly more Fruit than we now experimentally find, we need only suppose that the first Branch of a Graft will bear ten Buds in the first Year, and that each of those in the following Year will yield a Branch with ten Buds, and so on for twelve Years together, which is but a small part of the Years that many Trees attain to; there will be then found in the last or twelfth Year 1000,000,000,000; or a thousand times a thousand Millions of Buds upon the same Tree, each of which, according to the Nature of Trees, will produce one or more Fruits.

It must not be here objected against us, that such a Tree which produces Branches from all its Buds, would become a thick, close and confused Wood, insomuch that it would be able to yield no Fruit at all; because, besides that no Body can tell how the Growth or Increase of Trees would have been, in case they had been free from the Curse, the Augmentation only of the Length of the Branches between two Buds would have solved the same. And if we should suppose, for Argument sake, and for a greater Concession, that the three uppermost Buds of each Branch should only be Wood-Buds, and that the seven undermost should produce Fruit in their Season; there will be after this manner likewise Air and Room enough between every Branch of the Tree; which after having stood twenty Years, without reckoning the Fruits of the intermediate Years, would be able to yield in the 20th or last Year, a great many thousand Millions of Fruits from so many Buds.

Yea, that at present there are innumerable Buds that remain useless and fruitless upon Trees, may be seen by lopping the most and greatest Branches of one that is strong and sound; where one shall see a vast Number of young Branches peeping out at several Places. Now that they cannot shoot out but at the same place where there were Buds first, may appear plain enough to any one that but takes the Pains of slitting a slender Branch through its Bud lengthwise, by which he will be convinced, that in the Buds only are the Passages through which the Wood-Fibres or Vessels can run outwards. Besides that, there may be many others that escape our Sight; as on both Sides, in the Seam of each Branch where it is fasten'd to the Wood, there are two Buds that few People have observed: Which, if the Branch be cut across, of the thickness of a Crown Piece, do almost always afford two Fruit-Branches; or only one on that side of the Tree that the Person who cuts it has a Mind to produce it, especially if with his Knife he cuts away the other Bud. [See *La Quintinye*, Part IV. Cap. XVII, and XXI.]

They that would be informed of something almost incredible concerning the Fertility of Trees, may consult the Transactions of the *Royal French Academy*, for the Years 1700, and 1701, where he will likewise find the same proved as to Sorrel, Parsly, and other Garden-stuff, by a Calculation made upon the Number of Branches and Sprigs, cut off from Trees and other Plants,

Plants, and by counting the Seed found in each Branch thereof, and in particular the wonderful Fruitfulness of a Grain of Wheat, in many Ears exceeding the Number of those we commonly find produced thereby : But we have dwelt too long upon this Subject, and therefore shall pass forwards.

SECT. XXXV. *Convictions from the foregoing Observations.*

To conclude ; Let any one who has read the foregoing Sheets, and particularly what we have quoted from the *Transactions* of the *French Academy*, tell us whether he be not convinced that the Plants by their Structure are disposed to much greater Encrease than they really produce. Certainly the Gentlemen, Members of the said Academy, who so diligently and nicely observe every thing, do own, that they are convinced and satisfied therewith, by ushering in a new Dissertation with these Expressions ; *No Plant does ever arrive to its entire Perfection, in comparison of the Parts with which it is furnished.* [See the *Memoirs*, 1701. p. 326.] From whence the foregoing Objection is solved ; it appearing thereby, that altho' there were incomparably more Men in the World, the Plants would be more than sufficient for their Food, if they were as fruitful as they are capable of being by the present Structure of their Parts. And it is also true, that there must be a Cause or Power in Nature, whereby among so many thousand Plants, in so many thousand Years, there has been hardly one but what has been hinder'd from doing what it seemed to be made for, that is, from putting forth all the Buds contained in them, and the Fruit that should proceed from thence. Now let an Atheist, or Infidel, shew us the Reason and the Necessity why this Obstruction should have any place in Nature, notwithstanding that the Structure and Faculty of all Trees does unquestionably tend to the contrary. If any Body should pretend to ascribe this to any defect in the Sun, Air or Earth, it would be very probable, that in so many Climates and Soils there might at least one Tree have been found capable of exerting all that Fruitfulness to which its natural Structure had disposed it. But this not being so any where, it must be owned, that the thing itself shews, that those who deduce it from the Curse of an angry GOD, as his Holy Word has taught us, do furnish us with an Argument that gives the greatest Light to that which is, and would otherwise remain obscure to every Body, tho' it should not be allowed to be true. However, that which can be by no means denied, is, that that Sentence which was pronounced in the beginning of the World, has been hitherto undeniably and incessantly executed ; and that so illustrious a Man, who had so much Honour to lose, as the Writer of the Holy Scriptures, must have had more than a Humane Certainty of what was afterwards to happen in Nature, who durst, with so much Assurance, foretell a thing that was likely to be opposed by all Men of Judgment and Understanding, from the beginning of the World to this time : For 'tis beyond all doubt, that so long as the World has lasted, every Man that has concerned himself in the least in the Business of Agriculture, has exerted his utmost Diligence to find out Methods to increase the Fertility of all useful Plants, and to diminish the same in the hurtful ones.

SECT. XXXV. Of Sea-Plants.

Now it seems proper that something should be said here about the Plants that grow at the Bottom of the Sea, of which they that would see a brief Account, may find it in the *Transactions* of the *French Academy* for the Year 1700. where it will appear like so many Wonders, to see them springing out of something that has no resemblance of Roots, and in Places entirely unfruitful; forasmuch as being formed of a smooth, flat, roundish Body, with Parts like Leaves, without any Appearance of Fibrous Roots, they adhere to Rocks, Stones and Shells, and other hard Bodies, thro' which there does not seem the least Sap to be conveyed for their Nourishment. Mr. *Tournefort* reckons up four several Kinds of this Sort of Plants in the abovemention'd Place.

Now that which is to our purpose in this Matter, is, that in order to convince those that deny the Divine Perfections, that Plants are neither produced by Chance, nor by any ignorant necessary Causes, the Great Creator thereof has been pleased to shew hereby; *First*, That whereas all other Plants seem absolutely to require to live in Air, his unlimited Power, which only operates according to the Council of his own good Pleasure, will not be bound by such Laws; causing for that very End certain Plants to grow and live in the deepest Bottom of the Sea, where all others would certainly die. And, *Secondly*, to shew that mere Chance can have no place here, He has furnished them with all the Instruments that are requisite for the Growth, Production, and farther Structure of a determinate Sea-Plant. The same Proof has been likewise used above in the Comparifon between Fishes and other Animals that live in the Air: and it appears from both, that this Wisdom is not confined either to Number, forasmuch as the Fishes and Sea-Plants are innumerable; nor to Kind, since there is so great a Variety of both; but that it does all things for its own Glory, and in Conformity to its own Pleasure.

SECT. XXXVI. Convictions from all that has been said above.

Now to draw a Conclusion from all this, and to see what those Mathematicians, who stand in the first Rank among the Enquirers into Nature, have thought upon these Matters, we cannot do better than to quote the Expressions of Mr. *Huygens* in his *Cosmotheoros*, p. 18, and 19. No Body, I think, will deny that there is something greater and more wonderful in the Structure, Life, Manner of Growth, and Production of Plants and Animals, than of lifeless and insensible Bodies; tho' these latter may be more remarkable for their Magnitude, such as Mountains, Rocks, Seas, and the like. Moreover, in both those kinds of Animate things, the Glory of the Divine Providence and Wisdom appears much more differently and eminently. For tho' a Disciple of Democritus, or of Cartesius, should perhaps say, that in order to shew how every thing that we see both in Heaven and Earth has acquired its Existence, nothing more is necessary than Atoms, or little Particles of Matter and Motion; yet he will in vain endeavour to apply the same to Plants and Animals, nor be able to bring any thing probable from their first Existence

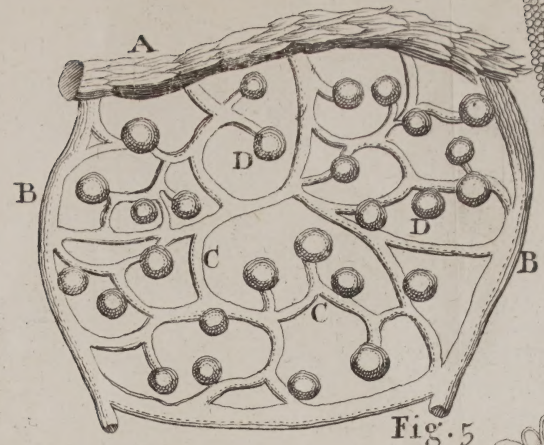
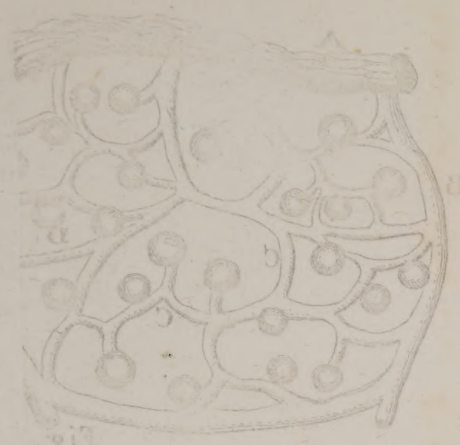


Fig. 5

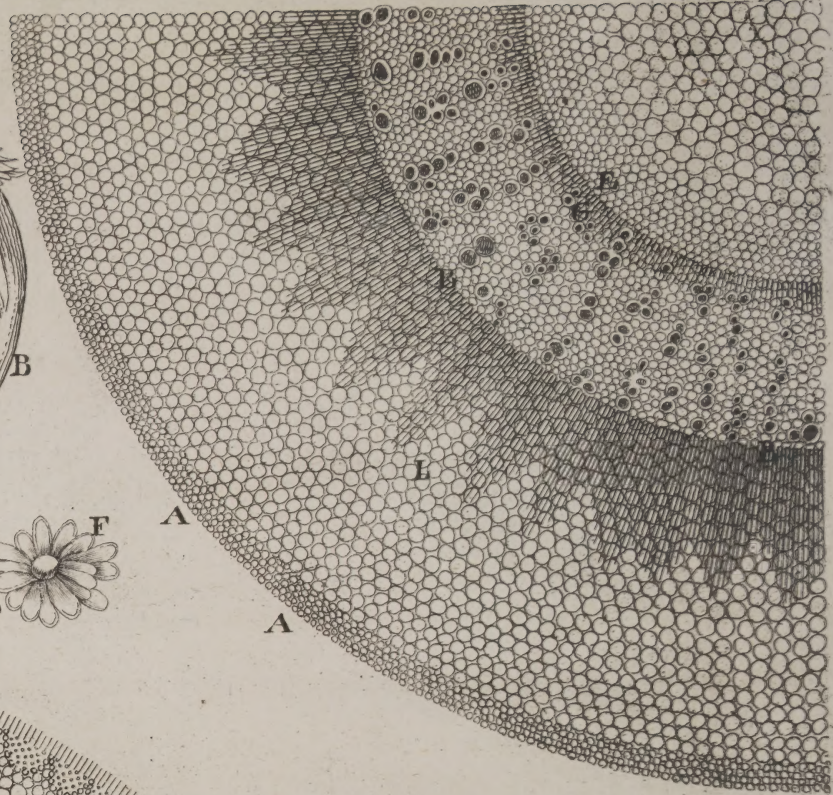


Fig. 3

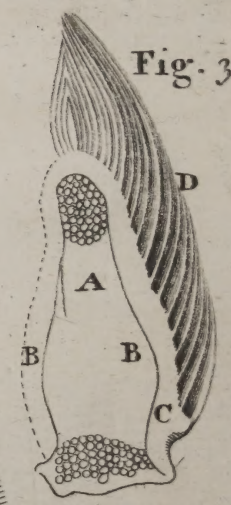
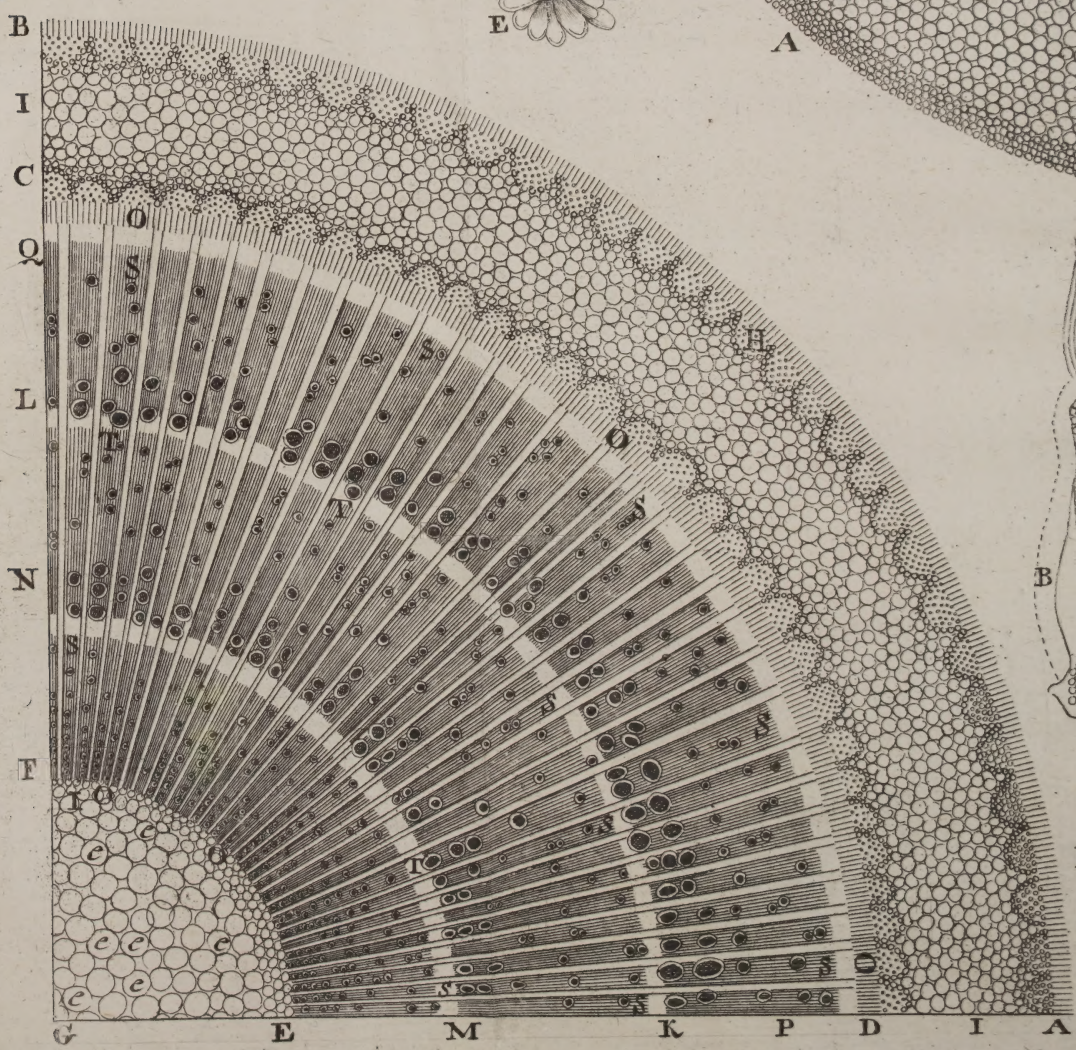
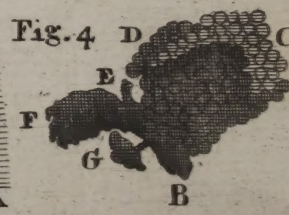


Fig. 4



Existence and Structure : Since it appears but too plainly, that such things can never proceed from a simple and accidental Motion of Bodies, forasmuch as all things are found therein to be adapted to certain Ends and Purposes, with the utmost Foresight and penetrating Knowledge of the Laws of Nature and Mathematicks; to say nothing of the Wonders of their Production.

I thought this Passage, of which kind I could have produced many more from great and good Philosophers, very proper in this Place; *First*, Because an unhappy Atheist might learn from hence how vain that Expectation is wherewith many of 'em are wont to flatter themselves, namely, That Men of the greatest Judgment have entertained the same Sentiments with them: Since we here meet with so famous a Naturalist, and one so highly esteemed by the learned World, with whom few of these Infidels can have the Confidence to compare themselves, speaking after a manner entirely different from their ill-grounded Opinions of the Divine Wisdom and Providence. *Secondly*, Because what we have just now quoted, shews with how much reason Atheism ought to be suspected by itself of Error and Falsity, since we see such great Mathematicians openly acknowledging that which an Infidel must deny, if he would quiet his own Mind. *Thirdly*, Every one that has read this Book of Mr. *Huygens*, must likewise own, that he does therein make a very careful Difference between what can be proved *True*, and that which is *Uncertain*, and can only pass for mere *Conjecture*: Since this great Mathematician expressly declares, that he would not have several of the Opinions which he there proposes, to be received for more than Guesses and Uncertainties.

Now let an Atheist examine himself whether he can by far alledge so much Probability for his Sentiments, as is to be found in these Conjectures, and let him compare the one with the other.

This worthy Author (that we may carry the Comparison yet farther) lays down in his *Cosmotheoros* some settled Mathematical Truths, and which Experience has render'd certain; and shews how his Conjectures may be made to agree therewith: Now what has an Atheist ever done like this, who never could advance any other than his own simple Notions for a Foundation to his Sentiments?

Moreover, if Mr. *Huygens* supposes, that it cannot be proved to be impossible in Nature, that there is Land and Sea-Animals, Plants, and the like in the Planets; he shews likewise, by an undeniable Experience, that something analogous is found upon this Globe. On the contrary, an Atheist maintains, that such surprising Master-pieces, as Animals and Plants are produced by Chance, at least without the Wisdom of the Maker; in which, however, so many well adapted Instruments, and so many different Motions, all serving to the same Purpose, are to be seen: Notwithstanding which, he has never yet been able to shew any thing like them in Works of much lesser Skill and Artifice, such as Watches, Mills, or even in the simple Structure of Houses and Chambers, which for the number of Instruments and multiplicity of Motions, fall infinitely short of any living Creature or Plant.

Finally, Notwithstanding all these things, this Gentleman confesses all his Speculations to be no more than Conjectures; whilst the Atheist, that cannot advance near so far, and who has the analogous Experiments perfectly against him, will have his Notions pass for irrefragable Truths, even with the Danger of everlasting Misery.



CONTEMPLATION XXIV.

Of the Visible Heavens.

SECT. I. *Transition to the World in General, and to the Heavenly Bodies in Particular.*

TO ascend now to that wonderful Structure of the glorious Heavens, and to shew from thence in a most convincing Manner, to all such as still doubt whether there be a Creator and Ruler of the Universe; there should seem nothing more to be required, than to lift up our Eyes, and only to Contemplate the Firmament without Prejudice, and therein the incredible Greatness of that unmeasurable Space, and of the Lights that are placed in it; and besides, the wonderful Splendor of them all, the particular Influences which the Sun and Moon, among others, have upon our Globe, their unspeakable swift Motions, hardly to be comprehended by human Imagination; and in the whole, the just and exact Observation of so many Laws and Ways to which such a number of Bodies have been subject for so many Ages, through such vast and unknown Spaces, and with such a terrible swift Motion as far exceeds that of a Cannon Bullet, and without being in the leastwise conscious thereof themselves: And this ought certainly to make an Atheist acknowledge, in case no Adorable and Powerful Direction had place in all these matters, and these Bodies, with respect to their Magnitude and Velocity, were only moved by Chance, that they might likewise fall foul upon, or run against each other by the same Chance; and therefore that it would have been much better for him never to have been born, than to live in a continual Fear, that something like this should happen to the Earth, which is his Dwelling-place.

SECT. II. *Convictions from the Sight thereof.*

AND tho' one should not carry one's Thoughts so far; let an Atheist suppose (to make use of the emphatical Proof produced by Cicero, in his Book of *the Nature of the Gods*) that from the Beginning of his Life he had been always shut up in the Cavern of a Mountain, in which he had seen no other Lights than little Lamps, nor no other Colours than those of disagreeable Rocks; and that he should at last, through a Crack in this Mountain, or by any other

means

means come to look up into the Air, and have a Sight of that Fire-Ball, so full of Lustre and Beauty, the glorious Sun moving in the Heavens, and not only enlightening and warming this whole visible Globe of the Earth, but likewise rendering it fruitful, and capable of supporting both Men and Beasts; and besides all this, should see the lovely Green of Trees and Fields, and the charming Colours of such a Number of different Flowers; could he help being exceedingly surprized and amazed, and forbear thinking how unconceivably Great and Glorious the CREATOR of all these Things must be?

SECT. III. *The Sun proved to be bigger than the Earth, by the Eclipses.*

Now how strong and irrefragable a Proof soever may be drawn from the mere Contemplation of the Heavens, that it must have been a Great and Adorable CREATOR by whom these noble Bodies, and particularly the Sun, has been made, and by that means, so many Benefits and Advantages daily communicated to this our Globe; yet there is a great Error, which has hinder'd almost all Men from judging of these Matters according to Truth: It is that childish Prejudice which causes us to look upon the Sun to be a Body of the Dimensions or Breadth of about a Foot, or a Foot and a half at most.

But those who know by the Eclipses of the Moon, that the Shadow *A L Z* (*Tab. XX. Fig. 2.*) which the Sun *D G*, by shining upon one Side of the Earth, casts on the other Side, grows continually smaller from *A Z* to *L*, and runs out to a Pyramidal or Conical Figure *A L Z*, the Point or Vertex of which is at *L*, may, without knowing much of Opticks (whereby the same is proved) quickly infer, that the Sun *D G* is much greater than the whole Globe of the Earth; for if the Sun were in its Diameter only as *b b* equal to the Globe of the Earth *A Z*, it is plain that the Shadow, being then equal at *A M N Z*, would be every where, or at *M N*, as big as at *A Z*, and always remain so.

And in case the Sun's Diameter were as *a a*, less than that of the Earth *A Z*, it is plain enough that the Shadow of the Earth would become continually larger towards *P O*, and farther.

So that since it appears, by undeniable Observations in the Eclipses of the Moon, that the Diameter of the Shadow at the Distance of the Moon, is not equal to that of the Earth, nor becomes bigger when farther from it, but that growing continually lesser, it makes the Pyramid *A L Z*, it will entirely satisfy those that understand this, that the Sun *D G*, is bigger than the Earth *A Z*.

The Knowledge of this may perhaps in some manner deliver People from the aforesaid childish Prejudice, and raising their Astonishment at the Power of their Creator, make them consider the Sun in its true Magnitude. But this will be done much more effectually, when they know that, according to undoubted Astronomical Observations, we may safely suppose the Sun to be above a hundred thousand times bigger than the Earth. I know very well that this will appear altogether incredible to those that are unexperienced in

Astronomy; 1st, Because the Antients have not allowed the Sun to be more than 166 times bigger than the Earth, and some not so much. 2^{dly}, Because the Disagreement among the Astronomers themselves, concerning the Sun's Magnitude, is the Cause that their Conclusions have little or no Weight with ignorant Persons.

To remove this Stumbling-block, we shall endeavour, as far as the Brevity of this Discourse will permit, to shew the Certainty of what has been advanced; and tho' we can't easily know the exact Magnitude of the Sun, yet it will appear plain enough, that a Hundred Thousand Globes of the Earth being put together, will not be larger than the Body of the Sun. But they who know this by the Principles of Astronomy, may pass by the following Demonstration, and proceed to *Se^{ct}. IV.*

SECT. IV. *The Magnitude of the Sun, proved from Astronomy.*

A Brief Demonstration of the Foundation of the Astronomical Conclusions about the Magnitude of the Sun.

THAT the Astronomers in their Calculations of the Bigness of the Sun, do proceed upon the same Principles and Foundations, as the Geometricians in measuring the Height of a Tower, a Hill, or the like, is obvious to all that understand any thing of Mathematicks. For which cause we may be equally certain of the Conclusions of the former as of the latter, provided that the Astronomers can make their Observations as justly and accurately as the Geometricians.

To prove this Assertion a little more clearly:

I. They take the Semi-Diameter of the Earth A B (*Tab. XX. Fig. 1.*) for an Unit, in order to determine the Sun's Magnitude B G, with respect to the same.

II. They observe, after different Manners, (which we shall not here describe) the Angle A C B, which is made at the Center of the Sun C, and takes in the half Diameter of the Earth A B. This they call the Angle of the *Parallax*, because, if we look along the Lines A C and B C, which make this Angle (and consequently from the Superficies of the Earth A, and from its Center B) to the Center of the Sun C, the said Center C, seems to cover the Point I, to those that look at it from A, and the Point F in the Heavens K L, to such as look at the same from B. This Difference of Sight they call the *Parallax*; and forasmuch as the Angle A B C is thereby determin'd, they are used, for Brevity sake, to call this Angle the *Parallax*: And when they have found this Angle A C B at any Height of the Sun above the Horizon, they compute how much it amounts to when the Center of the Sun C is in the Horizon A I; and this they call the *Horizontal Parallax*.

III. This Angle was first observed from the Antients down to Tycho Brahé, to be about ————— } 03 Min. 00 Sec.

But by Longomontanus, a Disciple of Tycho Brahé, reduced to ————— } 02 Min. 40 Sec.

And lastly, by Kelper, after various Observations, farther reduced to ————— } 01 Min. 00 Sec.

IV. After-

IV. Afterwards another Method of Observation being found out, which was not liable to so great Mistakes as the former, to wit, by the Moon's Distance; *Ricciolus* has found, that the aforesaid Angle does not exceed 30 Seconds or half a Minute.

And this is also counted a great Concession, since, according to Mr *Whiston*, it does not exceed 25 Seconds, 10 Thirds. And *Wendelinus* brings it yet down to 15 Seconds.

V. There is another Method brought into Practice by Monsieur *Cassini*, and Monsieur *De la Hire* in France, by Mr. *Flamsteed* in England, and other great Men elsewhere; to wit, by Telescopes arm'd with *Micrometers*, whereby, without any Danger of falling into so many Mistakes, the said Angle A C B may be observ'd with the utmost Exactness, in case it can bear, by reason of its Smallness, any Determination by us that dwell upon the Earth.

From whence the said Angle is computed by *Flamsteed*, (vid. *Whiston*, *Prælect. Phys. Mathem* p. 276.) by *Cassini*, (vid. *la Hire's Tab. Astron.* p. 8.) by Sir *Isaac Newton*, (vid. *Gregory Astron.* p. 336.) to amount to but 10 Seconds.

VI. From all which 'tis plain, that in Proportion, as the Means have become more certain, and the Instruments of measuring more exact, it has been observ'd, that the Angle A C B of the Parallax of the Sun, has constantly grown less and less.

And therefore that these abovemention'd Differences, that have occur'd among the Astronomers, have only proceeded from the Moderns using better Methods, and more exact Instruments than the Ancients; but they are by no means to be accounted Disagreements, as some unskilful Persons have call'd them, since the Antients have only shown thereby how far they had attain'd, and the Moderns, how much farther: And this is the more remarkable, because the said Differences have only been found between the Antients and the Moderns; but so far as they occur between Antients and Antients, and Moderns and Moderns, that have made use of the same Methods and Instruments, they are hardly worth the naming.

VII. Now to proceed. Since Astronomers have found in the Triangle A B C the Side A B, or the Semi-diameter of the Earth, with the Angle of the Horizontal Parallax of the Sun A C B; and knowing that the Angle B A C is a right, when the Center of the Sun C is in the visible Horizon A I, they have found in this Triangle, two Angles and one Side; wherefore, by Trigonometry, they may find out the Line B C, or the Distance of the Sun from Earth.

VIII. Now this Distance B C of the Sun from the Earth being known, which is likewise one Side of the Triangle B D C, they still seek for two Angles in the same, they being here necessary to compute the Semi-diameter of the Sun D C.

IX. To find this, they observe with their Instruments (which, by the way, exceed very much in Exactness those of the Antients) the Angle D B G, containing the whole visible Breadth of the Sun, and this they term the *Apparent Diameter* of the Sun.

The half whereof is the Angle DBC, or the *Apparent Semi-diameter* of the Sun, so called, because it contains the half of its Diameter.

X. There has not occur'd, in the Course of Ages, so great a Difference in this, as in that of the *Parallax*; and consequently likewise according to these three times, which we have remark'd among the Observers before about the *Parallax*, (when the Sun is in its middle Distance, that is, between the farthest from, and nearest to the Earth) the apparent Diameter of the Sun, or the Angle DBC, is computed by

<i>Ptolemy</i> , to be	31 Min. 20 Sec.
<i>Copernicus</i> , at about	32 Min. 45 Sec.
<i>Tycho</i> and <i>Longomontanus</i>	31 Min.
<i>Ricciolus</i>	31 Min. 56 Sec.
<i>Huygens</i>	30 Min. 30 Sec.
<i>Newton</i> , who much approves the Observation of <i>Cassini</i> } and <i>Flamsteed</i> }	32 Min. 15 Sec.
<i>La Hire</i> , about	32 Min. 11 Sec.

XI. So that the highest Computation of the apparent Diameter amounts to 32 Min. 45 Sec. and the lowest being but 30 Min. and 30 Sec. the Difference is no more than 2 Min. 15 Sec. the half of which being taken for the Angle DBC, produces only a Difference of $1\frac{1}{2}$ Min. that is, about $\frac{1}{15}$ Part of the whole.

XII. Whereas the greatest *Parallax* being of 3 Min. and the smallest but of 6 Sec. the former is above 30 times bigger than the latter, as we have shewn above by *Numb. III, IV, V.*

XIII. And from hence it is manifest, that the Variety of the Observations in the apparent Diameters may produce some, tho' but a very small Difference; but in the Angle of the *Parallax*, it will occasion a very great one in the Magnitude of the Sun.

XIV. Finally, forasmuch now that in the Triangle DBC, is found the before-given Side BC, or the Distance of the Earth, and the half apparent Diameter of the Sun, or the Angle DBC; and moreover, the Angle BDC being a Right Angle, because the Line BD touches the Circle DOG at D; it follows, that in the said Triangle DBC, there are found two Angles on one Side, whereby the third, DC, or the sought for Semi-diameter of the Sun may be found.

XV. We might now, after this manner, from these and the preceding Concessions, compute, first the Distance of the Sun from the Earth BC, and afterwards the Bigness of its Diameter DC. But since our View here is only to shew the Magnitude of the Sun, and the Difference thereupon between the Old and Modern Astronomers; but not so much to enter into any Discussion of the Distance thereof, we shall make use of a more concise Method, which is nevertheless attended with a Mathematical Certainty, and will be obvious to such as are experienced in Geometry.

And this consists in the following Proportion, or Rule of Three; in which we shall use the Angles A C B and D C B in the stead of their Sines, which indeed will be most agreeable to Geometrical Exactness; but because there results no considerable Difference from it, and yet the Calculation is much more convenient, we shall use it as other Astronomers have done. And thus it proceeds:

As the Angle A C B, or the Horizontal Parallax of the Sun : Is, to the Angle D B C, or the apparent Semi-diameter thereof :: So is the Earth's Semi-diameter A B : To the Sun's real Semi-diameter D C.

And this Rule does not only obtain with respect to the Sun, but likewise to all other Heavenly Bodies whatsoever.

XVI. So that according to *Tycho*, taking the Parallax }
3 Minutes, and the half apparent Diameter $15\frac{1}{2}$ Min. the Semi- }
diameter of the Sun is greater than that of the Earth A B, — } $5\frac{1}{2}$ times.

And these Numbers being cubed, (forasmuch as Spherical)
Bodies are to each other as the Cubes of their Semi-diameters) }
the Sun is bigger than the Earth ————— } 138 times.

XVII. According to *Ricciolus*, the Parallax 30 Seconds : Is to }
the apparent Semi-diameter 15 Min. 58 Sec. :: As 30 : To 958 }
Seconds, or 1 to $31\frac{14}{15}$; and consequently the Semi-diameter }
of the Sun D C is greater than that of the Earth A B. — } $31\frac{14}{15}$ times.

This being multiply'd cubically, makes the Globe of the }
Sun bigger than that of the Earth above ————— } 31,000 times.

XVIII. According to *Sir Isaac Newton*, the Parallax 10 }
Sec. : Is to the apparent Semi-diameter $16\frac{1}{2}$ Min. :: As 10 }
Seconds : To $96\frac{1}{2}$ Seconds; and consequently the Sun's Semi- }
diameter is bigger than the Earth's ————— } $96\frac{1}{2}$ times.

And this being multiply'd cubically, the Body of the Sun }
exceeds that of the Earth about ————— } 900,000 times.

XIX. Finally *la Hire's* Proportion requiring 6 Seconds Paral- }
lax, they are 16 Min. $5\frac{1}{2}$ Sec. apparent Semi-diameter :: As }
6 Sec. : To $96\frac{1}{2}$ Sec. or 1 to $160\frac{1}{2}$; accordingly the Semi- }
diameter of the Sun is greater than that of the Earth — } 160 times.

And by cubing this Number, it appears that the Sun ex- }
ceeds the Earth's Magnitude at least ————— } 4,000,000 times.

XX. From all which compared with one another we may gather,

First, That the Semi diameters of the Sun have increas'd from full 3, or hardly 6; first to full 31, afterwards to full 96, and lastly, to 160 Semi-diameters of the Earth; which, to those that are not much vers'd in these Matters, since the Numbers are not great, may seem probable enough.

Secondly, But that the Globe of the Sun itself should grow from hardly 140 Magnitudes of the Earth, first to 31000, and afterwards on a sudden to 900,000,

900,000, and lastly, to the Size of four Millions of times greater than the Globe of the Earth, is such a surprising thing, that they who are not used to these kinds of Calculations, must needs judge it impossible, and think, that altho' all that has been said about the Semidiameters were true, yet this would appear a Mistake in Astronomy: But every one that understands Geometry, knows that one is as sure as the other.

So that we now see finally, that this Increase and Difference of the Sun's Magnitude, manifesting itself in the Sequel of Time, was principally and mostly occasion'd by the continual Diminution of the Angle of the Parallax, since the small Diversity in the apparent Semidiameters might indeed contribute something, but yet very little thereto. But its amazing Magnitude is now particularly to be ascribed to the Cubical Multiplication of the real Semidiameter thereof.

XXI. Since therefore all that has been advanced, carries along with it a Mathematical Certainty in the manner of computing, it remains only to be inquired, whether the latest Astronomers have likewise rightly observed that the Angle of the Parallax is so small, which we shall leave to the Study of those that think themselves concern'd therein; forasmuch as the comparing the three Ways that were in Use from the Times of the Antients to *Tycho Brahé*, and from him in the last Age by *Ricciolus*, *Wendelinus*, and others, and now by Messieurs *Cassini*, *Flamsteed*, and *la Hire*, would prove too great a Digression, and take up too much room here.

This is certainly true, and obvious to all that understand the Science of Astronomy, that the Antients, according to their own Confession, could hardly be certain to a Minute in their Observations of the Heavenly Bodies, even with their largest Instruments; and that the following Methods have had great Advantages above the former, both in proceeding more certainly, and in coming much nearer; because that the Angle, which was necessary to them for computing the Sun's Distance, was so much greater, comprising the whole Space between the Moon and the Earth, which is about sixty Times as large as the Semidiameter of the Earth, of which the Antients were obliged to make use, which renders the Mistakes of the latter in their Observations so much less than those of the former. But the Moderns, by the help of their Telescopes and Micrometers, seem to have brought this Science of Astronomy to as great a Perfection as it is possible for Men to do, making the Firmament itself serve them for a Quadrant by the means of the aforementioned Instruments and proper Pendulum-Clocks; and so, with no less Certainty than the former, they are able to make their Observations to a few Seconds.

SECT. V. *It may be shewn, with sufficient Certainty, that the Sun is above 100,000 Times bigger than the Earth.*

BUT if the Parallax of the Sun does still remain immensurable to those Observers that can measure every thing with so much Exactness, especially if they endeavour to measure it about the neighbouring Planets, *Mars* and *Venus*, which (if their Distance also do not hinder) have Parallaxes much greater

greater and more capable of Observation, and then make their Calculation of the Parallax from the Sun's and Planets Distances, (the Ratio whereof is better and sufficiently known to them) it may be inferr'd, that it consists of a very few Seconds or less, if they observe and discover it after this Manner. And therefore that we may conclude upon just and true Principles, that altho' these Magnitudes which the present Astronomers do ascribe to the Sun, can't be so nicely determin'd, by reason of the Smallness of the Parallax (as all of 'em, even the chiefeft, allow, and whereof I could produce many Proofs) nevertheless the same must be unconceivably great. And in case we should not admit of the 160 Semidiameters of *la Hire*, and consequently of the Magnitude of the Sun above four Hundred Thousand times bigger than the Earth, yet we can't think those of *Mr. Huygens* so much to exceed the Truth, who makes the half Diameter of the Sun equal to 110 of those of the Earth, and its Magnitude consequently 1.331,000 more than that of the Earth; which as, it is easy to compute, does require a Parallax of eight, or near nine Seconds.

Or we may come yet nearer, and take the Calculation which *Sir Isaac Newton* makes use of in his *Theory of the Moon*, which supposes the Sun's Semidiameter to be $96\frac{1}{2}$, and its Magnitude to be 900,000 Globes of the Earth. Yea, if we take that of *Flamsteed* and *Horrox*, of about 12 Seconds (*vid. Newton Princ. Mathem. p. 414*) which is twice as large as *Mr. la Hire's*; we shall find yet more certainly, that no considerable Error is committed in ascribing too great a Magnitude to the Sun, tho' that includes in its Semidiameter above 80, and in its Magnitude above 500,000 times that of the Earth.

Wherefore, supposing (as we have done *Seçt. III.*) that the Sun is 100,000 as big as the Earth, we may be sufficiently assured, that we rather make it too small than too great; since the Parallax in this Case of about 21. is at least bigger than 20 Seconds, and admitting with *Sir Isaac Newton*, the apparent Semidiameter to be $16\frac{1}{8}$ Minutes, we find the Sun's real Semidiameter to be barely $46\frac{1}{2}$. And that no Error is committed here in allowing too much to the Sun, as appears from hence, That the Observations (as *Sir Isaac* himself owns in the Place above) of *Kepler*, *Ricciolus* and *Wendelinus* don't allow the Parallax to be much greater than 20 Seconds; tho' they have not us'd the accurate Method of *Cassini* in their Observations, which renders this Parallax yet much smaller.

Again, because (as appears by *Seçt. IV.*) *Wendelinus* himself, after his Method, makes it 15 Seconds, which is so much less than 20.

Lastly, The Testimony of the so often prais'd *Sir Isaac Newton*, is of great Weight in this Place, who making the Parallax to be 20 Seconds, says, That he chooses rather upon that Occasion to make it too big than too little; whereby he does not obscurely insinuate, that the same ought really to be taken something smaller.

From whence then it again follows, that the Disagreement between the first and the last Astronomers does not prejudice the Truth of the Conclusions of the latter, about the determining the Sun's Magnitude; and that

it is not too great a Concession to allow it to be at least 100,000 times as big as the Earth.

SECT. VI. *Convictions from the foregoing Observations.*

TO resume then the thread of our Discourse : Can it now be imagined that such a dreadful Globe of Fire, which is above 100,000 times bigger than our Earth (and one might more truly say above a Million of times, according to the aforesaid Demonstration) has been produced by mere Chance, and for so many Ages continued to discharge those great Functions, of which all the Inhabitants of the Earth are daily sensible ? And can any one persuade himself that a Sea of Fire of so astonishing an Extent, could have been contained within its Bounds, and in the Order and State we find it in, without the continual Direction of a great and wonderful Power and Wisdom ? Whereas there is no Matter known to Mankind, which with respect to us operates with more Fury, and, if it be in any Quantity, more ungovernable than Fire, of which there comes down to us daily (as the Burning-Glasses prove) so much from the Sun, either in, or with the Light thereof. And ought not the *Hypothesis*, that Chance, (or something else that is entirely ignorant of its own Actions, is the productive Cause of the Sun) makes every one, even the boldest Atheist himself, live in a perpetual Fear that by so continual a Motion and Raging of such an unconceivably great Quantity of Fire and inflamed Particles, or something or other, by the Descent of a much greater Quantity at once of this Matter from the Sun, along the same Way in which its Rays proceed at present, every thing might be set on Fire on the whole Globe ; or that the Sun having consumed the Food of that Fire, might change its Nature, and cease to communicate its Warmth and Light to us ; by which Means the whole Earth would be turned into the most dismal Dungeon that any one can possibly conceive. How much more easie then and happy do these Men live, who acknowledging the Maker thereof for an Almighty GOD, and their Gracious Benefactor, know that every thing, and even this dreadful Globe itself of Light and Fire, can only stir and move according to the Good Pleasure of Him that is the Lover of Mankind ; and who, to deliver us from such a well-grounded Apprehension, has declared expressly in his holy Word, *Gen. viii. 22.* That while the Earth remaineth, Seed-time and Harvest, and Cold and Heat, and Summer and Winter, and Day and Night shall not cease ; which Promise has been made good for so many thousand Years.

SECT. VII. *The Sun's Distance from the Earth.*

NOW if we pass on from the Magnitude of the Sun (of which I hope those that understand what has been already said are fully convinced) to its Distance from the Earth, to the end that we may likewise therein rectify those mistaken Notions, which even from our Childish Years we have conceived about it, and which we can scarce fancy to be more than the Space of a Mile from us, an unlearned and unexperienced Person will not be less astonished than he was before, when he hears us declaring, that we do not

make too large an Allowance for the Sun's Distance, if we maintain for a certainty, that it amounts to above 1000 Semidiameters, or half Thick-
nesses of the Earth.

That the Sun is very far from this Globe, may be proved by the Sun-
Dials and otherwise, which we shall now pass by, only shewing, as we have
done before in *Seet. IV.* that the Disagreement of Astronomy, with respect
to the various Distances of the Sun, are only occasioned from hence, that
the Moderns are furnished with so much better Instruments or Methods for
observing the Sun's *Parallax* than the Ancients; so that the smaller this
continually appears to be, so much the greater is the Sun's Distance from the
Earth.

To set this Matter in a clearer Light, for the Benefit of those that are
not skill'd in Astronomy.

Let the Semidiameter of the Earth, *A B, Tab. XX. Fig. 3.* (as in *Seet. IV.*
Numb. VII.) be taken for an Unit, the Angle of the *Horizontal Parallax* of
the Sun *A C B* in the Triangle *A B C A*, being likewise known by Observa-
tions: Then, since *B A C* is a Right Angle, the Distance of the Sun from
the Earth, or from the Line *B C*, may be easily found by Right-lin'd Trigo-
nometry: This Operation will be readily perform'd by such as only under-
stand that Way of Computing.

Supposing then A C B to be the Angle of the Parallax.

With <i>Tycho Brahe</i> of three Minutes, we find the Distance <i>B C</i> }	1150
consist of Semidiameters of the Earth to the Number of _____ }	
With <i>Ricciolus</i> of 30 Seconds, barely _____	7000
With <i>Newton, Cassini, &c.</i> of 10 Seconds, <i>B C</i> , is full _____	20,000
With <i>Huygens</i> between 8 and 9 Seconds, _____	24,000
And with <i>La Hire</i> of but 6 Second, to full _____	34,000
And if (as has been done before) we suppose the Sun to be }	
100,000 times bigger than the Earth, a Parallax <i>A C B</i> will be }	
about 20 Seconds (computing the apparent Semidiameter of the }	10,000
Sun to be $32\frac{1}{4}$ Minutes) and the Distance from the Sun to the Earth }	
will amount to Semidiameters thereof, _____ }	

Now since we can be assured from the so exact Observations of the great-
est Modern Astronomers, that the Parallax *A C B* is not more than of 20
Minutes, we may conclude with the same Confidence as a Geometrician can
measure the Distance of any two Places on the Earth, not indeed how
great the true Magnitude of the Sun, and how far its Distance is from us;
but it may be concluded by a Geometrical Certainty, beyond all manner of
doubting:

First, That the Sun is one hundred thousand times as big as the Earth.

And, *Secondly*, That its Distance from us is not less than ten thousand Semi-
diameters of the Earth.

SECT. VIII. *Convictions from the foregoing Observations.*

Now since it is indisputably true, that if the Sun had been placed much nearer to the Earth than we find it, nothing less could have been expected than a Total Conflagration thereof; and in case it had been much more remote, the Earth would have refused to produce its Fruits for the Support of those that dwell upon it. Can any one imagine again, that it is without Design, that this great and terrible Fire among so many numberless Places that it might have possessed in the great Space of the Universe, with respect to the Earth, should be fixed just there only, where it can cause so much Good and so little Harm to this Globe? Now if so unhappy a Philosopher (who maintains that the Sun has by meer Chance only acquired just that Place which is so useful and advantageous to the Earth, and all that is upon it) be a Mathematician, let him compute how many Places (in which the Sun might have been put by the same Chance) are to be found in the vast Convex of the Starry Heavens, and how many thousand to one it would have been, but that the Sun might have been fixed in some one of 'em, where it would have been entirely useless to the Earth.

SECT. IX. *The Earth, for Conveniency sake, supposed to stand still.*

THIS seemed to be sufficient to serve for a Conviction to such as still doubted of the Wisdom of the Maker. But since Custom, that seems to cloud our Reason with Stupidity and Insensibility, causes most Men to look upon this surprizing Wonder, like the Beasts without Attention, we must advise all those who still find themselves but little affected by the common Notices of what they see daily passes in the Sun, briefly to contemplate with us a few Particulars thereof with respect to the Earth, in which (we here declare once for all, that) we design to use the same manner of speaking and Figures that are agreeable with the Notions of *Tycho Brabé*, and are adapted to those Globes, by which a quiescent Earth and a Sun, moving about it are expressed. Those that embrace the other Hypothesis with *Copernicus*, namely, that the Earth moves about the Sun, may keep the same Meaning, and adapt it to their own Opinions, as they must do in the most, if not in all the Works of the greatest Astronomers; which, tho' they defend the Opinion of the Earth's Motion, yet in the Calculations concerning *Spherics*, or the Intersections and Angles which the Circles make, do likewise make use of the same Figures and Expressions as are founded upon the Immobility of the Earth; as is well known to those that have read their Books, and even the Writings of *Copernicus* himself.

SECT. X. *The Sun's Diurnal Motion.*

Now if any Body were to have his Dwelling upon the Globe of the Earth, *p e m f*, *Tab. XVI. Fig. 1.* and would make himself and all other Men happy, would not his first Care be (in order to avoid living in perpetual Darkness) that the said Globe should be enlighten'd? Now this is performed by the Sun (for Instance) at E. . . .

But

But when this is done, if the said Sun E stood always immoveably over the Point *e*, it would be there always Day, and exceeding hot; but on the contrary it would produce a perpetual Night and continual Cold at *f*, both which would be very inconvenient; forasmuch as in the last Case, tho' the Fertility of the Earth were not thereby diminished, yet all Pleasure, and in the first Case too, our most agreeable Rest would be obstructed.

To prevent all this therefore, it seemed again necessary, that this Sun should move round the Earth in such a Circle as E T F S E, in order to enlighten the same, and render it fruitful on all sides, and not to stand always still against one part of it: Now this happens by the same Sun's moving round the Earth every twenty four Hours.

SECT. XI. *The Sun's Annual Motion, Declension, and the Seasons of the Year.*

BUT now altho' the Sun should daily enlighten and warm the Earth, yet if it were not to move in the aforesaid Circle E T F S E, this ill Consequence might again be expected from it, namely, that every thing upon the Earth, within the Segment of the Circle *ef*, would be scorched by its Heat: and other Parts of the Earth upon which the Rays of the Sun fell more obliquely, would be render'd barren by Cold. Wherefore, that the greatest part of the Earth might not remain useless, 'twas requisite again, that the Sun in its Circulation should be serviceable to more parts of the Earth; and this again we see performed by the Sun, when it *recedes* or *declines* from the Equator E F on both sides, to A Northward, and to C Southwardly, whilst it always moves in the Circle A Y D, which the Astronomers call the *Ecliptic*, or *Sun's Way*. In this Circle it moves daily about one Degree, or the 360th part of a Circle from *West* to *East*, whilst in the same Space of Time it circulates from *East* to *West* at an equal Distance from the Equator E F, of which circular Motions the two extream ones, A B and C D, are here described; the last of which it performs in one Day, and that in the *Ecliptic* A Y D, in 365 Days, or in a Year; and it is this Diurnal Motion that produces Day and Night, and the Annual, the four Seasons of the Year: So that for Instance, 'tis Summer upon those Parts of the Earth, *a* and *g*, when the Sun is at A in its Way A Y D; and Winter when the Sun is at D; and Autumn and Spring when it is upon either Side of the Globe, in the middle between A and D.

SECT. XII. *The great Use of the abovesaid Motions.*

NOW by these Motions, besides the preventing those great Inconveniences, which would surely come to pass, if one continual burning Season, or an all-congealing Cold should always prevail in the same Region of the World; we find that most of the inhabited Places of the Earth are enlightened and warmed, according to the Manner and Measure that is most agreeable to the Nature of the People and Fruits that belong to it: This Diversity of Seasons, and Distribution of Heat and Cold, being also the Cause that some Lands are disposed and adapted to produce Spices, and some particular Kinds of Fruits, and other Countries others; whilst in the mean
time:

time this general Benefit is enjoyed by all Mankind, tho' disperſed over the whole Face of the Earth, by the Means of Trade and Shipping, by which every Nation may abound with thoſe Commodities that are not the natural Produce of its own Land.

SECT. XIII. *Convictions from the foregoing Observations.*

BEFORE I proceed any further, let me ask thoſe Philoſophers, who deny the Wiſdom and Goodneſs of the Supream Director of all things, Whether upon ſeeing any Royal or Princely Garden, they would ever pretend to ſay, that no Art nor Method had been uſed therein by the Gardener; tho' they ſhould obſerve, that in order to cauſe thoſe Plants to grow, which could not bear the Coldneſs of the Climate, Glaſs-Caſes, and Places with Stoves and other Conveniencies had been prepared to make 'em enjoy as much Warmth as poſſible; whiſt on the other hand, Arbors and ſhady Places were provided for other Plants that could not bear much Heat? And whether they would not be convinced upon ſeeing the great Variety and ingenious Diſpoſition of the Plants, Flowers and Fruits in ſuch a Garden, that it was not Chance, nor an ignorant Cauſe, but the Skill of a judicious Director, which had exerted itſelf in all theſe things, and whoſe Deſign was to cauſe the Maſter of the Garden by ſuch a coſtly *Apparatus*, and by contriving ſo many different Degrees of Heat, to reap the Benefit of his Labour, and to enjoy the Reſreſhment of thoſe Fruits which his own Climate and Air were not able to produce?

And can any one that is admitted to contemplate the Agreeableneſs of ſuch a Garden, tho' he ſhould not ſhare in the Fruits thereof, think himſelf obliged to thank the Owner for his Goodneſs, in ſhewing him the Secrets of his Art, and the wonderful Uſes of the Plants; and yet be no ways affected with the Goodneſs of the Great Creator of ſo Glorious a Body as the Sun is, by the Warmth of which, the whole Earth is turned into a Pleaſure-Garden and a fine Park, as may appear in *Tab. XVI. Fig. 1.* where the Torrid Zone, *a, b, c, d,* represents the Orangery, or Place in which thoſe Fruits that require the greateſt Heats are produced; whiſt others, that are contented with a more moderate, or even a cold Air, do meet with the ſame in the two temperate Zones, *a, g, h, b,* and *c, d, i, k,* or even farther towards the Poles in the Frigid Zones, *g, p, n,* and *i, m, k,* as far as the ſame remain fruitful. Thus we ſee that there is not only a particular Climate appropriated to ſuch various Sorts of Plants and Trees, but that which renders the Obligation which all Men lie under to the adorable Director of all theſe things ſtill greater is, that his bountiful Mercy does not only diſplay therein a wonderful Wiſdom even to the cloying with Pleaſure thoſe that ſeek for the ſame, but likewise that the Fruits produced thereby, ſeem to be made for no other Purpoſe, beſides the Honour of the Creator, than for Medicines to Men in their Sickneſs, and for Food and Reſreſhment to thoſe that are in Health; and in general, to render them happy in innumerable Inſtances, in which they are ſenſible of their Uſe and Convenience.

SECT. XIV, and XV. *The Morning and Evening Twilight.*

BESIDES what has been already shewn to be so wonderful in the Direction of the Sun in its daily and yearly Course, let an Atheist judge again, whether it is without a determinate End and Purpose, that the Rays thereof passing from a thinner into a thicker *Medium*, are refracted and turned away from their true Course, in order to produce the Twilights of Evening and Morning; whereas otherwise, upon the Setting of the Sun in all Places, a bright Day would be immediately changed into a Pitch-dark Night? And it may be easily perceived, that it is so ordered on purpose to be useful to Men, the Organs of whose Sight would be very much prejudiced, if the Transition from much Light to much Darkeness were made all at once: But they that would be more fully informed in this Matter, need only look back to what we have said in the 17th *Contemplation* about it.

That which may be farther observed here, is, with how much Reason GOD, to convince *Job* of the Narrowness of his Understanding, has taken a Proof thereof from this Refraction of Light in the following Words; *Chap. xxxviii. v. 12. Hast thou commanded the Morning since thy Days? And caused the Day-Spring to know his Place? Which last Words are translated by Pool and others: Do you know perfectly the Place of Twilight?*

To make this more intelligible to those that are unexperienced in *Mathematicks*, we have shewn above, in *Tab. XIV. Fig. 3.* that the Sun A being under the Horizon EY, and casting its Rays AH upon the Air at H, the said Rays do not proceed directly, and in a strait Line to D; but by being inflected, and making an Angle AHF, they are turned aside to F, and refracted or broken at H, and thereby produce Day-break or Twilight to those that live at F. Now it is known to every one by numberless Experiments, that according to the greater or lesser Thickness or Density of the Air, which varies in different Places, and in the same Place too, at different times, for many Reasons, the Refraction does likewise differ: And therefore, that the Twilight, with respect to the extreamest Parts where it is seen upon the Earth, or in the Air, cannot be determined by any Body; so that the said Question seems to carry this Meaning along with it: *Did you ever truly understand the different Thickness of the Air, both in your own and other Climates of the World, or the greater or lesser Refraction proceeding from thence, and consequently the Variations of the Morning and Evening Twilights, which are the Result thereof; or have you any Command or Direction over it?* To which Proposition no Mortal will ever be able to return any other Answer, than that this has always been mysterious and impracticable to him; to convince holy *Job* whereof, was the Design of the Almighty.

Besides what has been just now said, there may be still added these Reasons, why 'tis impossible for Men to know exactly the Place of the Twilight: *First*, Because it seems necessary to be supposed, that the Sun is encompassed with a kind of an *Atmosphere*, or Circle of Vapours (as the Earth is surrounded with Air) which upon the Account of the Sun's Nearness, does always shine, and is enlighten'd with the Fire thereof. *Secondly*, That the Sun shining upon
the

the Particles and Vapours floating in the Air, the Rays are sent back from some of 'em, as it were from a Looking-Glass by Reflexion, to the People who begin already to enter into Night; both which contribute very much to the Production of the Morning and Evening Twilight. See concerning this, *Gregory's Astronomy*, p. 127. where that great Mathematician (as if he intended to corroborate our Interpretation) uses the following Expression: *For these Reasons the Bounds or Place of the Morning and Evening Twilights are not so certain:* Besides which, he alledges several other Causes of this Uncertainty.

SECT. XVI. *The Weakness of our Conceptions.*

NOW, since all the great Services which the Sun renders to Men, Beasts and Plants are not to be number'd, soasmuch as we see them daily renewed; and, as if we had been blind before, or remain'd always in Darkness, we should be struck with Wonder, and, as it were, transported at the Glory of the Sun's first Appearance; I have often stood amazed, how it was possible, that not only the Atheists (who act herein according to their Principles) but likewise others that acknowledge a GOD, and that pretend to worship him upon other Occasions, are so little affected with all the Advantages that accrue to them from the Sun: For instance, how few are truly thankful for this great Benefit, that GOD causes the Sun to rise in the Morning and enlighten the World, and to set in the Evening, and produce the Night, by the Shadow of the Earth, in order to give Rest to all Creatures that have been tired by the Labour of the Day; and so in other Matters.

But particularly even those who are now entirely convinced of the Magnitude of the Sun, and its great Distance from the Earth, by the Mathematical Demonstrations of the Astronomers, as well as by so many Places of the Holy Scriptures; such as *Pf. lxxiv. v. 16. Thou hast prepared the Light and the Sun.* And *Pf. cxxxvi. v. 7. To him that made great Lights;* and many others, have seen that the Spirit of GOD himself has appointed this great and glorious Body for a certain Proof of the infinite Power of the Maker and Ruler thereof; and yet they hardly seem to have formed a right Notion of it. Besides Custom, the Weakness of our Imaginations seems to be the principal Cause thereof, which is unable, as well by reason of the Smallness of many Creatures that we are forced to view with Microscopes, as because of the Greatness of these heavenly Bodies, to represent them properly to us: And tho' no Body that understands Demonstration can doubt thereof, yet every one will find how defective his Imagination is in forming just Ideas of their real Greatness or Smallness: Of this we have no Occasion to produce any Proofs; let every Man only examine himself, and see whether he does not discover within him, what many of the greatest Mathematicians are obliged with Shame to confess, that they themselves experience concerning this Matter: See what *Mr. Huygens* says about it in his *Cosmotheoros*, p. 124, and 125. who, to obviate this Weakness of the Humane Imagination, endeavours to make use of another Means, to impress more strongly upon our Minds the Greatness of the Works of our adorable Creator, and of the Distance of the Sun from the Earth; shewing, that if we suppose with him, that the said Distance amounts

to 12000 Diameters of the Earth (which yet is much less than what the Modern and most Accurate Astronomers do with good Reason maintain) a Bullet shot out of a great Cannon, and moving in an equal Degree of Velocity, will be 25, or at least 24 Years in passing from the Earth to the Sun.

SECT. XVII. *How much Time is required for a Cannon Bullet to pass from Earth to the Sun.*

NOW that what has been advanced by Mr. *Huygens* does not exceed the Truth, will appear,

I. Because, according to the most exact Mensuration by the *French* Mathematicians, a Degree of a Great Circle upon the Globe of the Earth amounts to 57060 *Toises* or Fathoms of six Foot; from whence it follows, that the Diameter thereof amounts to 6538,594 of the like Fathoms, according to the said Mr. *Huygens* and *Whiston* in his *Praelect. Astron.* p. 13.

II. This being multiplied by 12000, the Distance of the Sun from the Earth, amounts to 78,463,128,000 of *French* Fathoms.

III. Now by the Experiments of *Mersennus*, a Cannon-Bullet advances in a Pulse, or the Second of a Minute, about a hundred of the aforesaid Fathoms; it therefore requires 784,631,280 Seconds to pass with the like Swift-ness from the Earth to the Sun.

IV. This Number is somewhat smaller than 788,940,000 which are the Sum of the Seconds in Twenty-five Years, if one allows to each of 'em 365 Days and 6 Hours, as may appear by the Calculations of the said Mr. *Huygens*.

SECT. XVIII. *How much Time is required for a Ship, or any living Creature that can run Fifty Miles in a Day and a Night, to pass from the Earth to the Sun, and Convictions from thence.*

NOW if the Swift-ness of a Cannon-Bullet should too much dazzle any one's Imagination; let him suppose a nimble Animal, such as a Horse, a Deer, a Bird, as also a Ship, either of which, if they can advance Fifty Miles every Twenty-four Hours, will require at least 1000 Years, either to run, fly, or sail such a Space as is between the Sun and the Earth; which may be easily computed, if one again supposes:

I. That the Sun is distant from the Earth 12000 Diameters thereof.

II. That a Degree, according to a Pilot's Calculation, being fifteen *Dutch* Leagues, the Circumference of the Earth will amount to 5400, and its Diameter to 1718 *Dutch* Leagues.

III. This being multiply'd with 12000, the Product of *Dutch* Leagues between the Sun and Earth, will be 21,616,000.

IV. This being divided by 50, or the Miles that a Ship will sail in a Day, or a Horse run, the Amount will be 412,320 Days, or about 1129 Years.

I thought I could not do amiss in being something the more large upon this Subject, and in shewing the Sun's Distance from the Earth after more

than one manner; since Mankind are wont, upon this Occasion, to represent to themselves a Giant like a Dwarf; and the great Firmament, and those glorious Bodies which it contains, and especially the Sun, with respect to its Magnitude and Distance, incomparably smaller than they really are, and consequently make the dreadful Power of the CREATOR Contemptible, instead of Wonderful and Infinite.

SECT. XIX. *The Swiftnefs of Light.*

LET the Atheist now go on with us, and contemplate that Wonder of all Wonders, that surprizing Creature the LIGHT, in its Properties only, so far as they are known to us, and in the first Place its unconceivable, and (if it had not been proved experimentally, its altogether) incredible Velocity.

It may perhaps appear strange to many, and even not to be admitted by most, if we should affirm that Light requires some Time for the Parts of it to descend successively from the Sun to us, and in that manner to be emitted from all Parts of that Glorious Body: Forasmuch as the chief Philosophers of the last Age, and many others of this, to whom the latest Observations of the Astronomers are not yet known, have thought, and with great Appearance of Truth too, that Light moved much after the same manner as a Stick lying between the Sun and us, whereof one End being protruded from the Sun, the other in an Instant, and without any Space of Time, would be likewise moved; so that properly, and according to this Hypothesis, the Light does not come down to us from the Sun, but that which is near and about us is only put into a continual Motion by the Sun, or by the Intermediation of their suppos'd celestial Matter. But they that are of this Opinion, will be yet much more shock'd, if we should tell them, that this Light is not only derived to us continually from the Sun, and that it requires some Time to pass to us, but even that it is protruded with so great a Swiftnefs, that it does not take up more than half a Quarter of an Hour, or about 7½ Minutes to pass from the Sun to us, that is to say, to run so many Millions of Miles.

SECT. XX. *An Experiment to prove that Light really moves and comes from the Sun.*

AN actual Proof that Light moves, and that even when the Rays of it are collected in any Quantity, it will protrude Bodies it meets in its Course, and, as it were, blow them away, may be found in the History of the Royal Academy of Sciences, 1708, p. 25. where Mr. Homberg relates, That a light Matter, such as the *Amiantus*, or Plume-Allum, being suddenly brought into the Focus of a Burning-Glass upon a Wood Coal, was driven off by the concurring Rays of Light; and that the Spring of a Watch, one End of which fasten'd in a piece of Wood, being likewise placed in the Focus of a Glass of twelve or thirteen Inches, the Rays struck against the loose End of it, and caused it to move backwards and forwards, just as if it had been thrust with a Stick.

Now this does undeniably prove a great Swiftneſs of Light; yet this amazing Courſe of it, as it ſurpaſſes all Imagination, ſo with many would it exceed all Appearance of Truth, were it not that the ten Years Obſervations made by Mr. Romer, upon the Eclipſes of Jupiter's Satellites, had put this Matter ſo much out of Diſpute and Doubt, that the greateſt and moſt accurate Mathematicians have been forced to admit it upon the Strength of thoſe Experiments.

It ſhall ſuffice here, that we may not ſwell this Diſcourſe too much, to produce only the Teſtimony of Sir Iſaac Newton, tho' we could likewiſe add many others: Theſe are the Words of that Gentleman in his *Princ. Philoſ.* p. 231. *Prop. 96. Lib. 1. in the Scholium. For that Light is puſhed on ſucceſſively, the Parts of it following each other, and that it paſſes from the Sun to the Earth in the Space of ten Minutes (in the ſecond Edition he has alter'd it to ſeven or eight Minutes) is now certain by the Appearances of Jupiter's Satellites, and confirmed by the Obſervations of ſeveral Aſtronomers.*

And when afterwards he publiſhed his *Opticks*, which are proved and illuſtrated by a Number of wonderful Experiments, we find him ſpeaking after this Manner, in the Eleventh Proposition of the Second Book of the Third Part, p. 236. *The Light is tranſmitted in a certain Space of Time from the illuminating Body, and employs about ſeven or eight Minutes in its Courſe from the Sun to the Earth:* Whereupon he adds the Proof, the firſt Words of which are, *This was firſt obſerved by Romer, and afterwards by others, by Means of the Eclipſes of Jupiter's Satellites:* In his ſecond Edition of his *Opticks*, he only allows about ſeven Minutes for this Paſſage of the Light.

They that deſire to ſee this more largely proved, may conſult Mr. Huygens, in his *Treatiſe of Light*; Mr. Whiſton in his *Præleſ. Aſtronom.* and others. Beſides, that the Impoſſibility of the contrary Hypotheſis has been already ſhewn both by Newton and Huygens.

It is ſufficient for us, ſince we cannot ſtand here to deſcribe the Particulars of Aſtronomy, to ſhew that this has been proved to be an unconteſtable and certain Argument by the moſt accurate Inquirers into the Nature of Light, and that the boldeſt Atheiſts have no Reaſon to doubt thereof, unleſs they underſtand nothing of Mathematicks, or are ignorant of the laſt Discoveries about the Properties of Light; or if they would be pleaſed to read the aforemention'd Aſtronomical Lectures of Mr. Whiſton, p. 229, and 230. where the *Reſtilinear* progreſſive Motions of the little Particles of the Light are largely handled and proved beyond all doubt; and where he ſhews, according to the nicest Obſervations, that in half a quarter of an Hour's time, the Light paſſes thro' all that Space that is between the Sun and the Earth. And this being allowed, let them reflect with themſelves, whether it be credible, that it is by meer Chance, and without any Direction, that Bodies protruded with ſuch an amazing Swiftneſs, can always obey ſo many Laws without once varying in their unconceivable Progreſs, as it has been obſerved with reſpect to Light upon ſo many Occaſions; of which more hereafter.

SECT. XXI. *What would be the Consequence, if the Rays of Light should become a Solid Body, and the Parts thereof adhere to each other.*

I SHALL here add, that I have been exceedingly affected with the Consideration of the dreadful Velocity of Light, as often as I thought that if once so many Particles thereof should adhere to each other, so as to compose a little Body, weighing no more than the tenth part of a Grain, they would exert as great a Force by the Swiftneſs of their Motion in striking upon any earthly Body, as a Bullet of twelve Pound Weight ſhot out of a great Cannon.

Now that it is not impoſſible that Light ſhould become a ſolid Body, ſeems to be proved by that Matter which we at preſent call a *Phoſphorus*, which ſeems to conſiſt altogether, or for the moſt part, of a combined Fire or Light; foraſmuch as if we put the ſame into Oil of Cloves, the Light thereof cleaves to the Oil, and cauſes it to ſhine, as it is known to the Chymiſts.

And now, that no body may think ſuch a dreadful Force improbable, which we ſuppoſe to be in the deſcending Light, in the aforeſaid Circumſtances, let him ſuppoſe:

I. That Light paſſes in half a Quarter of an Hour, or 450 Seconds, from the Sun to the Earth, which has been ſhewn above to amount to the Number of 78,463.128,000 *French Fathoms*.

II. It follows then, that this being divided by 450, the Light paſſes thro' 174.362,506 thereof in one Second or Pulse. Let us ſuppoſe it, for the ſake of a round Number, to be juſt 174.362,500.

III. Now a Twelve-pounder Shot out of a Cannon is found to advance in the ſame time a hundred of theſe Fathoms.

IV. And it is manifeſt from the Laws of *Mechanicks* and the Doctrines of *Percuſſion*, that the Force of Projectiles, with reſpect to their Courſe and *Percuſſion*, are in the ſame Proportion to each other, as their Weights multiplied with the length of the Way which they make in the ſame Time.

Now for the ſake of thoſe that do not underſtand Mathematicks, we ſhall ſpeak a little more plain, and ſay, that a Bullet of ſix Pounds, which in a certain Time runs the Diſtance of 200 Fathoms, has twice as much Force as a Bullet of twelve Pounds, that runs but 50 Fathoms in the ſame Time; for 6 times 200 makes 1200, and 12 times 50 is but 600, or the half of 1200. After the ſame manner, a Bullet of 12 Pounds running a 100 Fathoms in a certain Time, has as much Force as a Bullet of 6 Pounds that runs 200 Fathoms; of 3 Pounds and 400 Fathoms; of 2 Pounds and 600 Fathoms, in the ſame Time, &c. foraſmuch as the Weight of each of theſe Bullets being multiplied with the Way that they make in the ſame Space of Time, does always produce the like Number of 1200.

V. From whence we may infer, That in caſe an Aggregate of Light by its Velocity does act with the ſame Force as a Bullet of 12 Pounds; then in order to find the Weight of the Light neceſſary thereto, this Rule will have Place.

Where-

Wherefore as the Length of the Way (or as 174.362,500 *French Fathoms*) which the Light goes in the Second of a Minute, is to the Length of the Way that such a Bullet runs in the same time (or to 100 of such Fathoms;) so is the 12 Pound-weight of the Bullet to the Pounds, or rather to the Weight of this Body of Light, that has the same Force.

VI. Working this Question by the Rule of Three, it will appear that the Weight which the Light will have upon this Occasion, will be $\frac{12}{1743625}$ of a Pound.

And supposing a Pound of 16 Ounces, to contain 7680 Grains, and those Ounces to be *Troy Weight*, the Weight of this Body of Light will be $\frac{92806}{1743625}$, or about $\frac{1}{18}$ of a Grain, as is said before.

SECT. XXII. *Convictions from thence.*

NOW in order to be convinced not only of the Presence, but likewise of the Necessity of a Divine Direction, since this dreadful Swiftmess of Light is known, and since we find by Experience, in thousands of Bodies, that Light will adhere to them, and become a solid Body, and they being kindled, it will appear again; let an unhappy Infidel once more ask himself, by what Law or Necessity of Nature it happens, that this Light never comes to be turned into a little solid Body, whilst it is in the Sun, and so descend to us with its usual Celerity; since Water is converted to Hail in the Air, and the Spots in the Sun seem to represent such a Cohesion of Parts. Certainly if Chance only had Place here, we cannot give the least Reason why it should not so happen, or why a dreadful Storm of these collected and compressed Particles of Light, should not overspread the whole Earth with utter Destruction in an Instant.

I shall only observe farther, in what dismal Apprehensions the haughty Atheist is forced to live continually, on account of these and other Phenomena of Nature, which, according to their deplorable Maxims, may daily befall them; and the opposite good Fortune of those, who, relying entirely upon the gracious Providences of the Director of all Things, know that nothing can befall, or touch them, without the Will of Him who loves them as his Children.

SECT. XXIII. *Light runs in strait Lines.*

ONE of the Properties of Light is its Motion in Right Lines, from whence, according to all Experiments, the Separation between Light and Darkness is justly deduced, and so likewise are the Shadows in *Perspective*.

To give an Instance thereof: It is known that the Rays (*Tab. XX. Fig. 3.*) proceeding from the Points of the Sun, A and B, and those that lie between, if they run directly forwards according to the Lines A P and B P; do form the Cone of Shadow, or Pyramid, C D P; whereas on, the contrary, if the Light did not move in strait Lines; but in all kind of Curves, as Sounds are propagated, there would be no Darkness or Shadow where the Light could have no Access, and consequently no Separation between Light and Darkness.

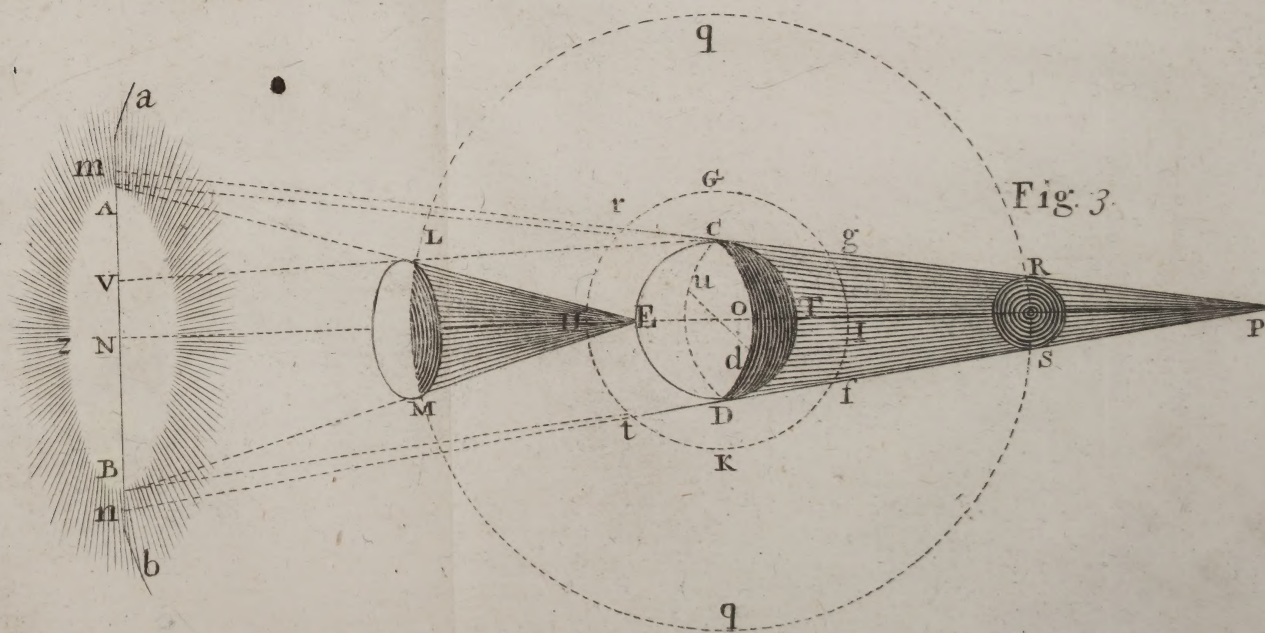
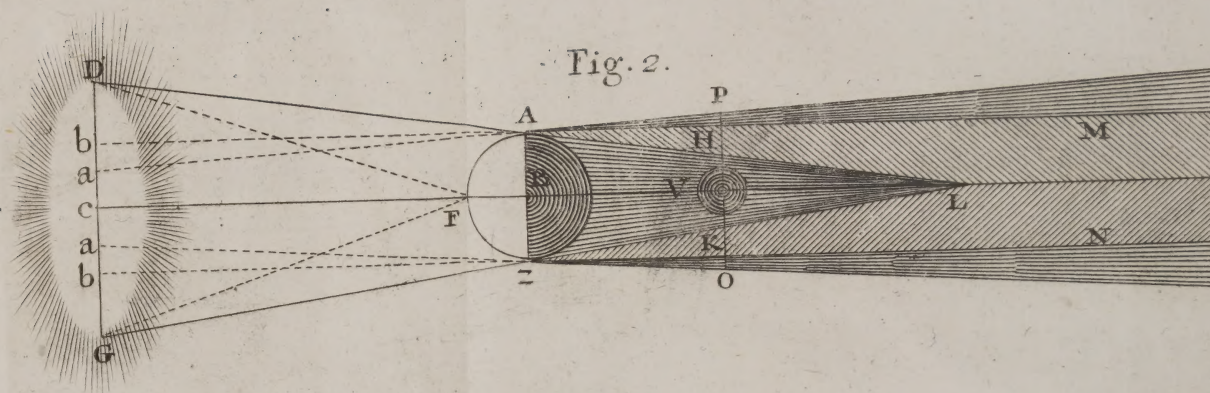
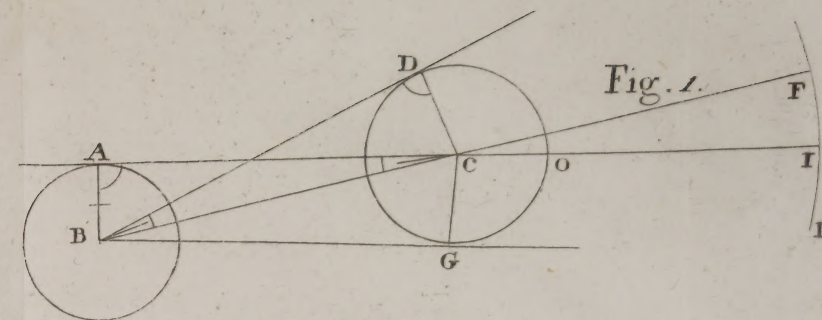
SECT. XXIV. *Experiments to prove that Fire is produced by Light.*

ANOTHER Property of Light is, that it is either Fire itself, or that it carries a great deal of Fire with it; and they that have a Mind to be surprized with the Powers and irresistible Motions that do appear in this Fire, and by which it is disposed (when united in any considerable Quantity) to consume every thing in the most dreadful Manner, let them take an Occasion to view the Force of the new-invented Burning-Glasses of Messieurs *Hartsoeker* and *Tschirnhaus*, or to read the Effects thereof. Lead and Pewter of a considerable Thickness are immediately melted by the said Burning-Glasses; wet Wood will burn in an instant; Brass and Copper, and even Iron Plates, will glow and melt presently; and many People know how much Time is requisite to cause hammer'd Iron to flow in the hottest melting Furnaces. Bricks, Pumice-stones, and earthen Vessels even full of Water will be dissolved and vitrified, and the Water at the same time almost boiled. *Asbestus*, or *Plume-allum*, (which, according to the Testimony of *Kircher*, will even bear the Fire of the Glass Houses without any Alteration) as also Gold, upon which all the Powers of our common Fire have been in vain employed hitherto, (and of which mention is made above) are turned to Glass in the Focus thereof. They who desire to see a more particular Account of these Matters, may consult the *Act. Lips.* 1687. p. 52. 1688. p. 206. 1691. p. 518. and the *History of the French Academy of Sciences*.

SECT. XXV. *Convictions from hence.*

Now let an Atheist, who knows from all this, that the Rays of the Sun do either consist of so devouring a Fire, or do carry a great Quantity thereof along with them; or, if he has ever observed the terrible Force thereof in its Effects; I say, let such a Man first represent to himself the almost incredible Velocity with which it comes down to us, and compare therewith the Force protruded by a little Flame of a Lamp, with which those that blow Glass do make it glow and melt, when they blow against it with any kind of Swiftmess; and then let him tell us, whether he can think, without Uneasiness, that this great *Solar* Body transmits Fire to us with so terrible a Velocity, and that it is only owing to meer Chance that there does not come down a greater Quantity of this dreadful burning Matter, and overturn and destroy the whole Globe of the Earth with an unextinguishable Flame. And if he imagines that this Earth is secured by fixed and necessary Laws of Nature from being consumed with Fire, how can he prove that since one Day is fair, and there is scarce a Cloud to be seen in the Sky, but the next is continually rainy and stormy; may there not likewise such an Alteration happen in the Sun to morrow, whereby every thing shall be burnt and consumed? There is nothing more required to keep such an Infidel in a continual Fear (if he be true to his own Principles) than the Consideration of that Danger with which he is threaten'd every Moment, if the Light of the Sun were moved by meer Chance only, and without a wise and merciful Direction.

fronting p. 428.



SECT. XXVI. *The Quantity of Light.*

Now let a Philosopher, who seeks for his unknown God in the true Disposition and Structure of the Things of this visible World, contemplate with us the amazing, and scarce conceivable *Quantity* of this *Light*, which is continually and incessantly transmitted from the Sun. We have said something upon this Subject before, when we treated of the Fire in the Air, and so far as it related to Light; but in order to be yet more fully convinced thereof, it is certain by Experience, that this Light fills our whole Air, and all that Space that is between us and the Sun at least, that, excepting the Shadows, there is no Place, tho' never so small, where it does not shew itself; [We express ourselves thus, to the end that no Body may except against the Word *fill*.] We can perceive it in the two lowest Planets *Mercury* and *Venus*; in the *Moon*, which moves about the Earth; and even in the three uppermost Planets, *Mars*, *Jupiter*, and *Saturn*: From whence it is farther apparent, that the Light does sufficiently fill all those Places to which it extends itself, since where-ever the Eye, or the Sun also, and those other heavenly Bodies may be placed, either the Sun itself, or its Light, which falls first upon the Planets, and is from thence reflected to us, may be seen, unless some intervening dark Bodies prevent the same.

Now if any one would examine how great that almost inconceivable Space is, which is continually filled from the Light proceeding from the Sun, (to say nothing here of the fixed Stars) let him suppose with the modern Astronomers, according to the Table by which Mr. *Huygens* made his *Automaton*, p. 447. that the Distance of the Earth from the Sun with respect to that of *Saturn* likewise from the Sun, is as 100 to 951; that is to say, *Saturn* is about 9½ times farther from the Sun than the Earth. Now 'tis plain enough, according to the modern Experiments, that the Distance between the Earth and the Sun amounts to about 12000 whole, or 24000 Semi-diameters of the Earth, and therefore that the Distance of *Saturn* being 9½ times as great, it amounts to 228,000 Semi-diameters of the Earth: For which Reason a Globe that would fill the Space between *Saturn* and the Sun, would contain 11,852.352,000.000,000 Globes of the Earth; these Globes being to one another as the Cubes of their Semi-diameters: So that now every body that considers this almost inexpressible Number of Globes equal to that of the Earth, that are requisite to compose one only equal to the Orb of *Saturn*, will easily agree, that the Space which is filled with the Light of the Sun, may be justly termed in a manner, unconceivable.

But if we go farther, and in order to demonstrate the Quantity of Light, consider together with this Vastness of Space, the Swiftness of the Light, which, as we have shewn before, passes from the Sun to us in 7½ Minutes, or about the eighth Part of an Hour, it will appear thereby, that it passes from the Sun to *Saturn*, or to the utmost Part of the Orb (a Sphere being described upon its Distance from the Sun as a Semi-diameter) in 9½ times so many Minutes, that is to say, in 1½ Hour; at least, if it be supposed that Light moves every where with the same degree of Velocity; for which reason

this

this great Orb will be emptied again in less than five quarters of an Hour, if the Light passes thus swiftly on; and therefore there must proceed such an unspeakable Quantity of Light from the Sun, as shall suffice in 24 Hours to fill so great an Orb about twenty times.

SECT. XXVII. *Convictions from thence.*

Now I leave it to an Atheist (who would not dare to maintain in the presence of wise Men, that his Candle, which served to light his Chamber in the Evening, came there by Chance) to judge himself, whether this glorious Sun, this wonderful Fountain, from whence for so many thousand Years there daily flows such an unconceivable Quantity of Light, can be believed by him to be produced without Wisdom; and whether all the Benefits which it continually occasions to those that inhabit the Earth, cannot demonstrate to him that a great Power (which ought justly to be dreaded by his Enemies) together with the Will as great to do Good to Mankind, had Place in the Production of the Sun: and whether so prodigious a Body, with continual Streams of Light flowing from it, and which by its dreadful Velocity seems capable to hurry all things away with it, has been able to serve for warming and enlightning Mankind, and by fertilizing the Earth, to preserve them alive, without a wise Direction and Government, for so many Ages?

Let it not be objected here, that the Sun by constantly illuminating a Sphere as big as the Orb of *Saturn*, or bigger (since it is credible, that the Light of the Sun diffuses itself beyond *Saturn*) and filling it so often with Light, and by having lasted as many Years as the World, may seem to have almost consumed all its Light; and so if not quite wasted, yet must be greatly diminished, since that is contrary to Experience: For in answer thereto, besides that no Body can be perfectly assured, that Light does not circulate the Blood in Animals, and after having performed its Course, comes back to the Sun again; which *Cartesius*, probably to avoid this Objection, seems to have thought; I say besides this, the Particles of Light may also be conceived to be so very small, that notwithstanding they do so far fill this whole Orb, that the Interstices or Spaces that are between, may remain entirely unobserved by us; yet being taken all together, they may not perhaps amount to the Quantity of one Grain of Sand; for which Reason there could be no Diminution perceived in the Body of the Sun in as many more Years or Ages.

Now as wonderful, and perhaps as incredible too as this may appear to many, it is nevertheless well known to the Mathematicians, that the great Space of which the Starry Heavens shou'd be supposed the upper Superficies, might be filled in such manner with corporeal Particles, that no one Ray of Light, how fine and slender soever, if it had but a determinate Magnitude, could be able to pass between the same, and consequently the said great Space would be absolutely opaque. All which corporeal Particles, if they were joined together, would nevertheless not only not make the Quantity of one little Grain of Sand, but even not of the smallest Part thereof, provided its Magnitude were likewise determinate. See *Dr. Keil's Introduction*, p. 54, 55.

SECT. XXVIII. *The Usefulness of the Divergency of Light.*

BUT if an Atheist should consider this continual and swift Stream (as it really is) proceeding from the Sun, not only as it brings Light always with it, but likewise an actual Fire; he must be forced to confess, according to the Experiments of the Burning-Glasses, that if this Light and Fire should descend to us in such a close and compressed Body as we find it is when the Rays of it are collected in the *Focus* of the said Glasses, the whole Globe of the Earth, with every thing belonging to it, would soon be reduced to a more dreadful Glowing, than Metals put into Fusion in a Furnace. Now it is sure enough, that this fiery Light is more hot and destructive near the Sun, than in the aforesaid *Focus*; so that in order to convert the Earth into a glowing Ocean, of which one can hardly think without trembling, nothing more is required, than that the Light should come down quite to us with its Rays, as compact and close united to each other, as it really is near the Sun.

This being laid down, let him seriously weigh with himself, whether he can think it to come to pass without Wisdom and Direction, that there is such a Motion communicated to the Rays of Light, and such a Law prescribed to them, which they have strictly obeyed hitherto for so many Ages, without once receding from 'em, tho' they themselves are entirely ignorant thereof, and whereby the Earth, and even the Universe itself have still been preserved from this all-consuming Fire. The Laws we mentioned to which Light is subject, are, that as soon as it comes from the Sun, the Rays of it are scatter'd and divided from each other, and continually more and more so, the farther they proceed in Right Lines. This the Learned expresses by the term of the *Divergency* of the Rays.

Of this we have spoken before, when we treated of the business of Vision, or Sight, and of Fire; and to avoid Repetitions, we should have passed it by here, were it not that from this Divergency or Separation of the Rays of Light, there seem'd to result a Proof, which is alone sufficient to cause an Infidel to see with indisputable Clearness, that there is a God that governs this now so beneficial and useful, but otherwise so terrible, Substance of Light and Fire, and thereby preserves from unavoidable Destruction, every thing that has Life and Being upon Earth.

SECT. XXIX. *The Properties of the Divergency of Light.*

WE shall only add the following Considerations to what has been said before upon the same Subject, to the end that those who are not versed in Opticks, and other parts of Mathematicks relating to Light, may have plainer Notions thereof: Let it be then supposed (*Tab. XXI. Fig. 2.*) that S is a Point in the Sun, from whence the Rays S a A, S c E, S c C, S d D, S b B, &c. in their Progress from S to A, C, D, E, continually diverge or recede from each other: Now there need not be much pains taken to shew that the same Rays, which at the Distance S B, fall upon the Plane Circle A E C D, when they are nearer to the Sun; and for Instance, when they

have proceeded no farther from it than Sb , are all within the Circumference of a smaller Circle $aecd$; and consequently, that the Fire of which these Rays consist, or at least which accompanies them, is so much thicker, or pressed together in the little Circle $aecd$, than in the great one $AECD$, as this last is bigger than the former; or to speak in the Language of the Mathematicians, the Heat which the little Circle $aecd$ undergoes, is so much greater than that which the bigger Circle $AECD$ feels from the same Rays, as the Square of the Distance of the great Circle, or of SB or SA , &c. is greater than the Square of the Distance of the little Circle, or of Sb or sa ; that is to say, when SB is twice as great as Sb , the Heat at $aecd$ is twice two times, or four times greater than at $AECD$; and so if SB be 100, and Sb 5, their Squares are 100 times 100, and five times 5, or 10,000 and 25; and consequently the Heat at $aecd$: Is to the Heat at $AECD$: : As 10,000 : To 25, or as 400 to 1; which is likewise confirmed by Experience.

From whence it is then manifest, that if one knows how much one Place is nearer to the Sun than another, one may likewise, according to this Rule, make an exact Calculation how much more Heat is produced by the Rays of the Sun at one Place than at another upon Occasion of their Distance; and generally that 'tis true, that by how much the nearer any thing is to the Sun, so much the greater Heat it must undergo from the united and compacted Raysthereof; as also the farther it is from the Sun, the less will it feel of its Heat.

Now as this is known to be true by all Mathematicians, let an unhappy Atheist consider in his Retirement, whether he thinks it can be by Chance, that a glowing Sea of Fire above 100,000 times bigger than the whole Globe of the Earth, is about the Sun at S , the burning Rays whereof SB , SA , SE , SC , SD , &c. come down with so unspeakable a Swiftmess incessantly (and therefore in such a Number as is hardly to be conceived) upon the Earth $ADCE$; and yet that this terrible Fire does not immediately, and in the most dismal manner consume every thing upon it.

'Tis true indeed, that the Distance SB , which is between the Earth B and the Sun S , being of the Length of 12,000 Diameters of the Earth, may contribute something thereto; but yet this beautiful Globe is by no means preserved from the aforesaid terrible Destruction by this only. To understand which, let it be supposed, that there comes down from the Point of the Sun S upon the Earth, the Rays sa , se , sb , sc , sd , &c. without Diverging, or in parallel Lines, and closely joyned together; or (to render the Notion thereof yet clearer) that the said Rays being near the Sun at the Point B , are diverged and separated from each other as they go, but proceeding farther, lose their Divergency; and descending down in their Parallelism, or Equidistance, from the circular Column $acmk$, it is plain that all of 'em will fall upon the Circle km , and there produce a Heat, which is so much greater than that which would be perceived in the great Circle $AECD$ from the same diverging Rays, as this last Circle is bigger than the little one km . This appears from the Burning-Glasses, the Force of which does only consist herein, that the Rays are collected into a smaller

Compass;

Compass; so that they give a clear Proof of this Truth, that the Rays of the Sun being collected into a narrower Compass, even at so great a Distance from the Sun itself as is the Earth, are yet capable of producing a terrible Heat. From whence then it does follow certainly enough, that it is not so much the Distance of the Sun, but the Divergency or Scattering of its Rays more and more, which chiefly diminish the force of Burning; and that the said Distance or Remoteness does hardly contribute more towards preserving the Earth from an entire Conflagration, than by the dissipating and separating the Rays more and more from each other, in proportion to the Length which they run.

SECT. XXX. *Two great Uses of the said Divergency.*

FROM this Divergency of the Rays of Light from all Points whatsoever (which must be considered as a Wonder by all Men) we may deduce these two Advantages, which the adorable Creator bestows upon us, and which we have before already hinted:

First, That the Earth is thereby secured from being consumed by the Sun.

Secondly, That by such Divergency all Bodies are enlighten'd on all Sides by the Rays that are scatter'd upon 'em, and thereby render'd visible to every one. Thus we find in *Vol. I. Tab. X. Fig. 1.* that the Rays of Light *K P* falling from the Candle *K* upon a Point *P* (for Instance upon the Point of a Needle) separate themselves from one another there, as well as at the Candle itself, and by that Divergence render the said Point visible all round about it.

SECT. XXXI. *Refractions, and their Uses.*

BUT forasmuch as (*Tab. X. Fig. 3.*) these Rays from *A*, diverging and filling the Space *A S T*, the same would also happen from all the other Points *N, L, M, B, &c.* of the Object *A B*, and therefore the same Rays diverging, for Instance, from *B* and *A*, will be entirely mingled with each other at *S O T*, and so represent to the Eye at *S T* a confused Light of all the surrounding Objects, but no distinct View of any one: there seemed therefore something to be still deficient to render the Light compleatly useful to us; and that besides the rectilinear and divergent Motions of Light, there was yet another Law requisite, by which all the Rays proceeding from *A* or *B* might be again inflected towards each other, and gather'd together in so many particular Points *a* and *b*, which has been already proved to be the sole Cause of distinct Vision.

Besides this, to the end that the Light may be as useful to us as possible, since the Sun when it Sets would turn the perfect Day in a very small space of Time into thick Darkness, and when it Rises, would change a Night, as dark as Pitch, in a few Minutes into a bright Day; by which means our Eyes passing so suddenly from one Extream to the other, might be much prejudiced and weaken'd, as Experience often shews; there seemed to be a

Means necessary to cause the Brightness of the strong Light of the Sun to advance and recede gradually; and this is brought about by the Morning and Evening Twilights.

Now I would ask an Atheist, who pretends not yet to be able to discover the wise Purposes of him that has prescribed such Laws to the *Light*, and which it strictly obeys, whether he could have found out a better way to avoid the abovemention'd Inconveniencies, than by enduing *Light* with the Properties of Refraction, whereby, as we have already shewn, the two aforesaid Difficulties may be obviated? And since they are actually prevented by this Method, what Reason has so unhappy a Philosopher to deny the Wisdom of the Creator and Ruler of so glorious a Body?

SECT. XXXII. *The Proportion of the Angles made by the refracted Rays.*

Now to shew that these Refractions of the Rays of Light can't be ascribed to mere Chance, let (*Tab. XXI. Fig. 3.*) a Ray *S O* proceed from the Sun *S* to the Superficies of the Water *F G*; and suppose from the Center *O* a Circle *F B G P* described as large as you will, it is experimentally true, that the Ray *B O* does not proceed strait forward to *R*, but at *O* makes the Angle *B O P*; for which Reason the same Ray being thereby refracted, proceeds from *O* to *P*, according to *P O*, which is termed the refracted Ray.

After the same manner the Ray *b O*, does not proceed strait forwards to *r*, but breaks at *O p*: Now whether these refracted Rays *O P* and *p O* do likewise run in strait Lines, or else as often as they meet with fresh Resistance or Reverberations are again inflected, we don't here determine.

Now I leave any one, that is reasonable, to judge whether he imagines it possible to happen without the Direction of an intelligent Being, that all the Rays *O S*, *O s*, and all others that with different Obliquity fall upon the Water *F G*, (as here at *O*, with so dreadful a Velocity, with which they are protruded, and being entirely ignorant of all things else as well as of themselves) can observe such a Law without once departing from it, that their broken or refracted Rays, *O P*, *O p*, do exactly ever take the same Way; that (supposing the Lines *A B*, *D P*, *a b*, *d p*, to be all at Right Angles to *ad*, which is likewise at Right Angles with respect to *F G*) the said *A B* and *P D*, as also *a b* and *p d*, will always have the same Ratio to each other; so that to speak more plainly, as *A B* is two or three times as long as *P D*, in all the other incident Rays, as here at *b o*, *a b* will be twice or thrice as long as *p d*; nor will there be, in so many Millions of Rays that fall in such various Obliquities upon *F G*, and penetrate into the Water, one single Ray to be found, notwithstanding their surprizing Swiftness, that don't perfectly follow this Rule, at least if all the Rays are of the same Kind.

SECT. XXXIII. *The Structure of the Eyes with respect to Light.*

AND as when we treated of the *Eye*, we mention'd the Properties of Light as an uncontestible Proof of the Wisdom of the Creator; so whilst we
are

are here speaking of Light, we shall briefly apply the Structure of the Eye, so far as it relates to Light, to the same Purpose; and the most obdurate Atheist, unless he absolutely refuses to listen to any convincing Proofs, is intreated by us, that he would again attend to what we have said in the Contemplation about *Vision*.

SECT. XXXIV. *The Power of Bodies to reflect Light.*

BUT now tho' Light should fall upon the Eye, and tho' the Eye were furnished with all the afore said Qualities for receiving the same; yet that whole Disposition, and all those Properties would be in vain, and the noble Globe of the Earth would be of no more Advantage to the Inhabitants, than it is to any Body now who is stark blind; unless besides all this, the Bodies upon which Light falls, had the Faculty of causing the same to rebound back from them, and to *reflect* the Rays thereof to all Places round about 'em.

Now since this Property occurs in almost all visible Objects, will an Atheist say, that this was likewise by Chance, or deny that the great End thereof was to render Bodies visible?

And if it should appear to him too absurd to ascribe all this to meer Chance only, let him then tell us, what Necessity there is in the Combination of Causes, why almost all Bodies do enjoy this reflecting Power, with respect to Light; whereas there are many which in relation to others that strike upon or against 'em, do not exert such a Power, nor drive them back again with any Repercussion. Thus we see, for Instance, that every thing which falls with any Degree of Swiftmess upon soft Clay, remains sticking in it, and is not reflected; and yet the contrary happens when those exceeding swift Particles of Light fall upon the same; for how small soever they be, they rebound from it, and thereby render the Clay visible. We might relate many more Wonders concerning this Matter, which we shall pass by here, having occasion to say something of them hereafter.

SECT. XXXV. *The Air Invisible.*

MOREOVER, since this Property of Reflecting Light, is in a manner common to all Bodies, excepting perhaps such as were black, (which by many is supposed to be occasioned, because Bodies so tinged do not reflect any of the Rays of Light that fall upon them, for which Reason they have no other Idea of this Colour but as of meer Darkmess.) Now must we not herein confess a wise Disposition of the Great and Gracious Creator, who, notwithstanding that he has made Water and many other fluid Matters visible, yet seems to have excluded the Air only, for the most part, from that Faculty, notwithstanding that that also in itself is visible like other Bodies, and seems to be very well adapted thereto by its Elastical and other Properties, as appears when we compress a great Quantity of Air in the Pump, and then suddenly let it out again by the Cock? Now let an Atheist ask himself, whether this can appear to him to be so order'd without any Design or Purpose? And since the Air itself being thus visible, and so far capable of stopping the Course of Light, would cause us to live as it were in a
continual

continual Fog, and hinder us from seeing conveniently most of the Objects about us, whether he does not observe, that this same adorable Wisdom does here interpose after a wonderful Manner for the Benefit of Mankind?

SECT. XXXVI. *The Wonders of Reflection.*

AND to the end that many miserable Philosophers, who think they understand so well the Laws of Reflections and Refractions, should not imagine that there are not more Wonders concealed in the same, and that their Understanding does perfectly extend itself thereto, let them give a satisfactory Reason of the Appearances mention'd by that accurate Philosopher Sir *Isaac Newton*, in his *Optics*, p. 238, and 346, *last Edition*; and tell us what is the Cause that the Light passing from a Glass, and falling with a certain Obliquity upon a Place from which the Air has been exhausted, does not proceed on, but returns back again to the Glass; and that when the Rays fall from the Glass upon the Air with an Oblique Angle of more than 40 or 41 Degrees, the same are likewise entirely reflected; whereas if they fall with a lesser Obliquity, most of 'em will pass thro' the Air, so that the Light which passes thro' the Air upon the Glass, can make itself a way thro' the same, and yet the Light that passes from the Glass to the Air in the same Obliquity seems unable to make itself a Passage in a Medium thinner, whereby to pursue its Course.

They that have a mind to see many wonderful Circumstances besides these, may consult the abovemention'd Places, and from the Experiments there related, may with Certainty enough infer, that we do not rightly understand the Nature of Light, with respect to its Reflections, whilst we only consider it as a Globe or Ball rebounding from any hard Matter.

At least it is evident hereby, that there are Laws in Nature to which the Light is subjected, of which perhaps none of the Naturalists, if they had not thus found them true by Experience, would ever have thought.

SECT. XXXVII. *Experiments shewing that Light may become a Solid Body.*

I MIGHT have here forbore to have enquired into certain Questions proposed by Sir *Isaac Newton*, in his *Optics*, p. 349. *Quaest. XXX.* where that Gentleman seems to incline to the Opinion, that Light, besides its being the most active Matter in Nature, may likewise become the Substance of palpable Things, and be converted into a solid Body: but since Mr. *Homborg* has put this Affair out of doubt by several Experiments recited in the *Memoirs of the Royal French Academy*, 1705. p. 122, &c. it seems not improper to shew here likewise this Use of Light. And,

First, That Light penetrates almost all Bodies, even those that appear obscure to the Eye, and passes thro' the same, as is sufficiently known to such as make use of good Microscopes, since almost every Object that has been viewed therewith, provided they are but thin enough, do in some manner become transparent.

The said Sir *Isaac Newton* tells us in his *Optics*, p. 223. That he has observed the same in a dark Chamber, when any Matter reduced to a proper Thinness, was placed before the Hole through which the Light would otherwise have passed; and he only excepts white metalick Bodies, which seem to reflect all the Light falling on them.

Secondly, If we suppose Flame to consist for the most part of Light, we see that it turns to a solid Body in the burning of Chalk, and especially in the making of *Minium* or Red-Lead from Lead-Ashes, which after having burnt and glow'd a great while, become more heavy.

Mr. *Homberg* likewise relates, that if Quicksilver, being reduc'd to the utmost Fluidity by Steel and Antimony, be put over a Fire in a Glass, the parts of the Fire will penetrate it thro' the Glass, and which may therefore be deemed a Light without any additional Mixture, will change it into a Powder heavier than the Quicksilver was at first, and be of such Proof against Fire, that it will bear glowing at least 24 Hours without any Evaporation; and when driven with a very violent Fire, it may indeed evaporate into Smoak, but will however leave a little Parcel of itself behind, which being formed by this Light in the Quicksilver, will assume the Qualities of a solid and malleable Metal: This may be farther confirmed by the Experiments made on the like Occasion by Mr *Boyle*, by which he shews how some Bodies, shut up on every Side in Glass, become more ponderous by the Fire or Light that passes thro' the Pores of the said Glass: But this is proved yet more plainly, and beyond all Dispute, by the following Experiment of the said Mr. *Homberg* in the abovemention'd Place, who having reduced four Ounces of *Regulus Martis* to Powder, placed it about the Distance of $1\frac{1}{2}$ Foot from the true Focus of the Burning Glass of the Duke of *Orleans*, stirring it about from time to time with an Iron Spoon; by the Heat of this Light there ascended a great Smoak from the said *Regulus* for the Space of an Hour, and then it ceased: And tho' one might expect, that by the loss of all those Particles which evaporated in Smoak, the Weight whereof would have been diminished; yet the contrary he found that the Weight of it was increased $1\frac{1}{2}$ Quarter of an Ounce, and some Grains, that is to say, about a tenth part of the whole.

Afterwards he placed the same in a greater Heat, or in the real Focus, which put the *Regulus* into Fusion, and then it weighed no more than $3\frac{1}{2}$ Ounces; so that he reckons that this loss of the half Ounce happening by the Evaporation and Smoaking, one may safely affirm, that the Light had first augmented it with almost the Weight of a whole Ounce, which by melting, and the Operation of such great Heat was dissipated again.

Now whether this last Calculation be just or not, it plainly follows from hence, that this *Regulus* had in the first of those Experiments gained by the Rays of Light, the Weight of almost half an Ounce over and above all that evaporated in Smoak; which clearly shews, that Light can conjoin itself to solid and palpable Bodies, and increase the Substance thereof.

But the Reader is desired to consider this as the first Sketch of a new Discovery: And I shall not endeavour any farther here to determine, whether we ought with those great Men abovemention'd, to consider Light as the chiefest

est and most active Principle in Nature. This however seems to be uncontestably true, that Light is either a pure and uncompounded Fire, or carries such a Matter along with it; and how much ought to be ascribed to the Activity of Fire, is sufficiently known to every one. Experience likewise teacheth us, how much all Plants and Animals depend upon the Influence of the Light of the Sun; insomuch, that if it cannot be said to be the only active Principle in Nature, at least it may be certainly reckon'd among the chiefest.

SECT. XXXVIII. *Optical Experiments passed over.*

I SHALL not amuse myself here to rehearse the common and known Experiments about Light, which the Science of *Optics* suggests as so many Wonders, tho' they furnish us with one of the greatest Proofs to demonstrate that there is a GOD who directs this miraculous Matter of Light, rendering it subject to such Laws, notwithstanding the amazing Velocity of its Motions, that even the greatest Mathematicians must stand astonished, when they see that all true Argumentation can deduce from it, performed by the same. Thus we see when it falls upon the Superficies of a Looking-Glass, that it paints the Object from whence it flows, as if it was behind the said Looking-Glass, where the Image is represented erect equally large, and at the same Distance as the Object: If it falls upon Spherical Convex-Glasses, it likewise makes behind the same a nearer and direct Image upon the Glass; and upon Spherical Concave-Glasses the Image will be sometimes erect, sometimes inverted, now greater, then smaller; one while it will appear before, another while behind the Glass, which may be shewn almost by Refraction in so many Changes thro' Convex and Concave-Glasses.

SECT. XXXIX. *A Dark Chamber, and Convictions from thence.*

NOW if any Body would with small Expence try an Experiment about the Operations of Light, let him make what they call a Dark Chamber, of which mention has been already made in *Contemplation XII.* by which means he will see upon a white Paper, or a Piece of Linnen held in the Focus of the Glass, that is fix'd in the Window, the Pictures of every thing that is on the outside of the Chamber, which will produce a very pleasing Prospect, especially if the Chamber looks upon a Flower-Garden; for then one may see the Flowers in all their Colours and Figures, painted upon the Paper, and their Motions occasion'd by the Wind; and if there be any Men or other Creatures in the Garden, it will be a natural Moving Picture.

NOW since every one can judge by a Picture, of the Art and Skill of the Painter, and can be assured by the exact Representation of the Object after the Life, that the Man who drew it was a great Master of Painting; let a miserable Atheist but only contemplate with us these Pictures formed by the Light, and tho' he were himself a very skilful Limner, let him tell us whether he, or any Man besides in the whole World, could copy a Piece, not only so very like, with such noble Colouring, so nicely adapted to all the Rules of a Mathematical Perspective, but also with all its Motion, as he may observe to be done in an Instant by the Rays of Light: And in case

he be obliged to own, as to be sure he must, that it exceeds all human Power, what Reason can he give with the least Show of Truth, why he should not confess an understanding Artificer in a Work which exceeds the Skill and Power of all human Invention: Whereas in other Works of much less Excellence, a Man would be justly esteem'd a Fool, if not mad, who should maintain, that it had acquir'd its Figure without any Knowledge. The rather, since we see that the Rays which represent the Colours of each of 'em so distinctly in the Chamber, pass all of 'em together thro' this little Hole and Glass; and altho' they be so numerous, and coming from the Objects, yet are they not jumbled and confounded with each other in this little *Defilee*, thro' which they pass together; a thing that is not easily to be credited, if we had not ocular Proof of it. And cannot then an unhappy Sceptic discover yet an over-ruling Power and Wisdom in this Direction of Light? What can be further done to extricate him out of this miserable Blindness.

SECT. XL. *The Properties of the Rays of Light, with respect to Colours.*

BUT before we take our leave of Light, we shall add something which seems to surpass even Wonder itself. Could any Body believe it, when he looks upon the bright and untinged Light of the Sun, that the same can be divided and distinguished into so many different sorts of tinged or dyed Rays, as the Great Creator has been pleased to communicate of primary Colours or simple Tinctures, or as the Learned call them, *Homogeneous Colours*?

And yet Experience teaches the same, as also that each of these coloured Rays suffers a particular Quantity of Refraction, and that the white, or rather the clear Light, is thereby split into different Parts or Kinds of Rays, which appearing singly, shew a *red, yellow, green, blue and purple* Colour; on which account these Rays are named by Sir *Isaac Newton*, *Red, Yellow, &c.* each of 'em according to their particular Colours, forasmuch as they are natural to them, and cannot be altered by any subsequent Refraction or Reflection.

Moreover, since all unmix'd Rays of the Sun do represent a certain Colour, and the whole Substance of Light consists of the said Rays, it seemed to be hardly possible, but that all these Tinctures jumbled together, must occasion an Obscurity to our Sight; forasmuch as Blue, Purple, Red, and other Rays, are far short of that Brightness which occurs to us in the pure Light of the Sun or Day; and yet we find that all these colour'd Rays that proceed from Light by Separation, being collected and mix'd with each other, do entirely lose their respective Tinctures, and together produce a clear and transparent Light, entirely like that untinged Light that comes down to us from the Sun: Which new constituted Light may be again, as before, divided into its colour'd Rays, which, if one will, being mix'd together again, shall the second time represent an uncoloured Light clear and transparent; concerning all which, the first Discoverer, Sir *Isaac Newton*, has treated largely in his *Opticks*.

Now I ask an unhappy Atheist, whether he can believe that Light has acquired these Properties either by Chance or ignorant Causes? Or whether he must not acknowledge, that those Men argue much more justly, who conclude from hence, that the great and gracious Benefactor of Mankind has produced all these differently colour'd Rays, to the end that the Beholder may be so much more agreeably affected and refreshed with the Sight of GOD's Creatures; and that he has placed in them the last Property, whereby all of 'em being mingled together, do compose a clear and transparent Light, to the end that the Obscurity of the Colours may not embarrass human Eyes?

Besides, his Wisdom and Beneficence must be acknowledged herein, that in the Parts which compose different colour'd Bodies, he has placed such a Disposition, whereby one Body, when this compounded Light falls upon it, is adapted to reflect only one, or some particular kinds of Rays; for Instance one only Red, another only Yellow, a third, both of 'em equally, and no other (by which a kind of a Gold-colour between Red and Yellow is generated) I say, to reflect these in a greater quantity, by which means each Body, according to one or more sort of Rays which it reflects, either Simple or Compound, represents its particular Colour, and from thence is denominated Red, Yellow, &c.

How strange soever this Language might have been to all former Philosophers, yet the same is at present put out of all doubt by the afore-quoted *Optics* of Sir Isaac Newton; who tho' he may be justly reckoned by every Body amongst the most famous Mathematicians of the World, yet to set an Example to these less experienced Gentlemen, that they should not too much rely upon Conjectures and Hypotheses, has proved the same to be unquestionably true, not by Demonstrations founded upon Arguments, but by manifold and exceeding nice Experiments. Now those that have a mind to read and try the same, may meet with 'em in the afore said Treatise of *Optics*, especially in the *First Book*.

SECT. XLI. *The Division of Light in Island-Chrystal.*

BESIDES the above-mentioned Divisions of Light, whereby it is split into various-coloured Rays, Mr. Huygens in his Treatise about *Light*, p. 61. and Sir Isaac Newton in his *Optics*, Query 25. p. 328. do shew us another Division or Splitting of Light, which it undergoes when it meets with *Island-Chrystal*; upon which, as soon as a Ray of Light falls, it is divided into two other Rays that preserve however the same Colour.

Of these Divisions or Splittings of the Substances of Light into several other Parts, as well tinged in the first Case, as simple or untinged in the second, I don't know that there was ever the least mention made, or Track to be found among the ancient Naturalists; nor that this Matter has been put out of doubt sooner than in the last Age by accurate Enquiries and undeniable Experiments.

SECT. XLII. *The Usefulness of the Moon.*

Now let the Reader return with us to *Tab. XXI. Fig. 4.* and suppose the Sun to be represented by A B, and the Earth by C D, in which Situation, as we have said before, the Shadow of the Earth, or the pyramidal Figure C P D makes the Night, it will not be then difficult for him to fancy the great Darkeness in which those that dwell at T must be involved ; forasmuch as not the least Ray of Light flowing from the Sun A B, can come to them directly, or in a strait Line.

Now if you will please to observe, that the Moon M being opposite to the Sun A B, is at Full to those that live at T, that is to say, they see its whole enlighten'd Side ; you will tell us whether you can think there is any Gratitude in those People that shall deny their great Obligations to Him who has furnished them with this Light of the Moon in such their Darkeness.

SECT. XLIII. *Convictions from hence, and the Eclipses.*

Now the only Evasion that such People can make, is, that all this happens by Chance, or by necessary Causes, and consequently that no Thankfulness is due : But if the Gracious Creator of the Moon had no Wisdom, nor the Benefit which Men enjoy from the Light thereof is not to be reckoned one of His great Views and Designs, how will they account for the following Particulars ?

I. That the Light of the Sun has a Property when it falls upon any Bodies (as here from N, the Center of the Sun, upon M the Moon) to rebound back from it again, and to produce a reflected Ray M T ; by which means those that would otherwise remain in the midst of the dark Cone C P D, are enlightned. Now that without this Faculty of Light there could be no Rays reflected from the Moon to our Earth, is plain enough.

II. Why is the Moon M, which is much smaller than the Globe of the Earth, placed at no greater Distance from it ; so that (as we see in *Saturn* and other great Planets) its Breadth and Diameter disappearing almost out of Sight, would be incapable to communicate any Light to us that could be useful ? And is there here no wise Purpose ? And since the Universe is so large, why is this Place, among Millions of others, just chosen out, whereby it is best besitied to render such Service to those who inhabit the Earth ?

III. How comes it that the Moon is not of such a Contexture as our black or dark-coloured Bodies are ; by which means it would be able to give little or no Light to us ?

IV. Why is it not a convex, globular and smooth Body, like Looking-Glasses and other polished Things, when (as those who understand *Optics* know) there would be no more than one Point, or at least a very little part of the Moon visible and capable of enlightning us ?

V. Why does not the Moon move according to the Line G H F S, which lies in the Plane of the Sun's Way N n ; by which means the same at G being opposite to the Sun, would never be seen Full, but would always be obscured and eclipsed by the Shadow of the Earth C P D, and on the contrary,

trary, the Moon being at F when it is dark or new, the Sun A B would be always either totally or partially covered and eclipsed thereby, at least the World reaps this Benefit by the Declination of the Moon's Way M H R S from the Plane of the *Ecliptic*, or Sun's Way N n, or G H F S, that the Places lying near the Poles may be enlightened by the Moon, whilst the Sun, being still under the Horizon, occasions such a long and dismal Night?

And moreover, does there appear no Wisdom therein, by which this continual Monthly Sun (as one may call it) is secured, to the end that Mankind may not be so often deprived of the Use thereof? How comes it then to pass, that the Moon's Way S M H R has just such an Obliquity with respect to the Plane of the Sun's Way, or G H F S, that, *First*, the most part of the Time that the Moon is at M, or directly opposite to the Sun, it is freed from the Shadow of the Earth C P D, and consequently from its Darkness, and that all that part of it that is turned to us, is seen at Full, and in its entire Lustre: *Secondly*, That when the Moon is at R, that is, in Conjunction with the Sun, and is seen at E, it is not hid from those that dwell upon the Earth?

VI. But farther, since now the Planes of the Sun's and Moon's Way H F S G and H M S R (placed in respect to each other after the manner of two Hoops laid obliquely upon one another) cut each other at two Points H and S; it follows, that when the Moon is not in its own Way at M, but at H or S, it will then be in the Plane of the Sun's Way: And when it happens at the time that the Sun is not at A B, but is directly opposite at *a b* to the Moon at H or S, and that the Sun and the Earth are in a Right Line n K; it may be easily gather'd from the Figure, that when the Night-Shade extends itself to E K T, the Moon being at H, will be thereby eclipsed and obscured; but when it is at S, it will then hide the Sun at *a b*, and so cause a Solar Eclipse to those that dwell at S.

SECT. XLIV. *The Advantages of Eclipses.*

BUT here seems an Objection to stand in our Way, namely, that if Light be so agreeable, and Darkness so terrible; and if all this be so order'd by a wise Governour of the World, why do these *Eclipses* or Obscurities of the Sun or Moon come to pass, since Light alone seems sufficient to furnish Man, tired by the Labours of the Day, with refreshing Rest?

Now to answer this, and to shew that in Eclipses likewise, how dark soever they may be, the most adorable Wisdom of God is displayed, we need alledge nothing more than what is already known to Astronomers from the Uses thereof.

And, *First*, that in the inquiring into the Course of the Sun and Moon, these visible Signs are oft-times so many Evidences, whereby we may know whether what has been said thereupon, in other Cases, is well grounded or not: Of this you may meet with many Instances among the Astronomers, which we shall not here relate.

Secondly,

Secondly, They administer Proofs of many natural Truths, which might not have been discover'd to us, without these Eclipses, or at least not so easily.

Thus we know that the Moon is less than the Sun, or even than the Earth itself, without any Calculation, only from hence, that (*Tab. XX. Fig. 2.*) the Earth's Shadow *A L Z* running like a Pyramid into a Point at *L*, is for that reason every where smaller than the Earth itself; or the Line *H K* is always shorter than the Diameter *A Z* of the Earth; and because the Moon *V*, passing thro' the Shadow, from *H* to *K*, is not only darken'd, but even remains frequently hid a long time in the same; which 'tis plain would never happen, if the Moon were only of equal Magnitude with the Earth.

From whence it likewise follows, that the Moon in itself is a dark Body, at least it is far short of the Clearness of the Sun, even tho' we should ascribe to the Moon itself that Flame-Colour which it sometimes shews in its Eclipses, as many have thought.

From hence it also appears that the Moon receives its Light from the Sun; forasmuch as when it has passed thro' the Earth's Shadow and *Penumbra* after its Eclipse, it appears again in full Lustre as soon as ever the Rays of the Sun can fall upon it.

Moreover, the Eclipses of the Sun teach us that the Moon is not only a dark, but likewise an untransparent Body, which appears by its hiding or covering the Sun.

Many such Observations might be shewn from these Eclipses; 'tis enough for us to have represented some of them, by which the Benefit thereof is proved in the Examination of the Creatures.

Yet if there be any Body that is not sufficiently convinced from hence, and it appears to him too small a thing, that the Inquirers into Nature are only benefited thereby (tho' the Honour and Wisdom of the Creator is best supported and magnified the same Way) yet he cannot avoid owning the great Use and Service thereof in other Occasions also; for since these uncommon Signs of the Heavens having been observed by all, or at least by many Men for many Ages, have been accurately noted by some, together with the Time when they happened; and forasmuch as those Times of the past Eclipses may be likewise determined by Posterity with the Help of Astronomical Calculations, it will easily appear from hence, that those Eclipses are, as it were, fix'd Land-Marks in the Series of Ages and Histories; from whence again, as from an undisputable Root of Time, a new Chronology may take its Date, and others, in which there is any Uncertainty, be likewise rectified thereby.

But the Usefulness of the Moon's Eclipses appears yet more particularly in determining the Longitude of the Earth; insomuch, that the Truth of many Maps and Descriptions of the Earth may be examined and corrected thereby, as has oftentimes actually happened, which is not only of very great Advantage to Geographers, but also of the utmost Importance to so many Seafaring

faring People, whose Preservation and Lives too often depend upon the Goodness or Badness of a Chart.

After having understood this right, it does not seem necessary to prove by more Circumstances, that the above-mention'd Objection will fall of itself, and that the Eclipses of the Sun and Moon are of great Use to Mankind.

Besides, that though we should not be able to shew all the Uses thereof, yet this is no Proof of any thing's being unprofitable, since such a Reason has no other Foundation than in the Ignorance of Men.

SECT. XLV. *The Light of the Moon is without Warmth.*

BUT to proceed: Is it not a Wisdom that has made and ruled the Moon with a Design of doing Good to Mankind? forasmuch as there is hardly any Light known to us which does not warm at the same Time that it shines; and since the Rays of the Moon seem to be no other than those that are transmitted from the Sun to it, and then reflected back to us; how comes it that the Moon-Light was neither *hot* nor *cold*, even then when the Rays thereof were collected by a great Burning-Glass into one small Space or *Focus*, which (according to the Experiment of Dr. Hook, *Aët. Lips.* 1707. p. 153.) was 500 times smaller than what they filled in their natural State? Thus we see likewise in the Experiment of Mr. La Hire, in the *Memoirs of the Royal French Academy* 1705. p. 455, that the Rays of the Full-Moon in *October*, collected by a Burning-Glass of 35 Inches broad, in its *Focus*, into a Space three hundred and six times lesser than what the same would have filled in their natural State, did not produce the least Alteration in a Thermometer (in which the Liquor was moved by Air, and which discover'd the smallest Increase of the Warmth thereof) tho' the Ball of it was held for a while in the said *Focus*: And we likewise find by the said *Aët. Lips.* 1697. p. 429. that the so famous Burning-Glasses of Mr. *Tschirnhaus* produced indeed a greater Brightness by the Rays of the Moon in the *Focus*, but not the least Warmth. Now could ever any Body have imagined that the Rays of the Sun, collected by a Burning-Glass, or reflected from the same, will burn so terribly; and yet that the same Rays rebounding from the Moon to us, do not appear to bring the least Warmth along with them, notwithstanding that by this kind of Glasses the Brightness of the Moon-Light is very much augmented in the *Focus* as well as that of the Sun.

But we shall have Occasion to say something more of this, when we come to the Contemplation of *Unknown Things*.

Now how advantageous it is to hot Countries, that this Light of the Moon produces no Heat, is obvious to every one who knows that if it was otherwise, and that the Rays of the Moon were likewise hot, that part of the Earth would be barren, and soon burnt up, since the descending Dews of the Night, by which it is now moistened, would then cease to fall down, and this Fire of the Moon would draw its Vapours upwards. Moreover, if the Night-Air were not fresher and cooler, and that the Rays of the Moon kept the same in a continual Warmth, it is plain enough how prejudicial it would be to the Health of all Men, and the hot Parts of the World would suffer great Inconveniencies thereby.

SECT.

SECT. XLVI. *The Moon's Magnitude and Distance from the Earth.*

I KNOW not whether it is necessary to shew in this Place, how much the Moon is smaller than the Earth, and how much the Light thereof (which in itself is hot, yet) by reason of the Distance is weaker, and less warm upon the Earth than at the Moon itself. But since the preceding Figures may be of use to us in this Matter, and the Grounds of this Calculation depend on that of the Sun, we shall briefly touch upon the same.

1. Let AB (as before in *Tab. XX. Fig. 1.*) be the Semi-diameter of the Earth, and DC now be that of the Moon; then will the Angle ACB of the Moon's horizontal Parallax, *when she is New, or Full*, according to Sir Isaac Newton, be at a Medium. ————— 57 Min. 30 Sec.

And its apparent Diameter DCG, according to the same. 31 Min. 30 Sec.
The half of which therefore for the Angle DBC, is ————— 15 Min. 45 Sec.

In the Fourth or last Quarter of the Moon, and at a middle Distance likewise from the Earth, Sir Isaac Newton again supposes,

The Horizontal Parallax, or the Angle ACB ————— 56 Min. 40 Sec.

The apparent Diameter, or the Angle DBG ————— 31 Min. 3 Sec.

The half of which for the Angle DBC is ————— 15 Min. 31 Sec.

Now since A and D are Right-Angles, made by a *Tangent* and a Semi-diameter, if we take the Earth's Semi-diameter AB for an Unite, we shall, by plain Trigonometry, find BC, or the Moon's Distance from the Earth to amount to;

At *New* or *Full*, barely 60 Semi-diameters of the Earth.

And at the *Quarters*, barely 61 of the same.

So that the middle Distance is about $60\frac{1}{2}$ thereof.

2. Now to discover the Magnitude of the Moon; we first find its Semi-diameter DC by Trigonometry aforesaid, amounting at *Full* or *New* to $\frac{m}{1450}$ or $\frac{63}{230}$, and at the *Quarters* to $\frac{231}{1400}$ Parts of AB, or of the Earth's Semi-diameter; both which do not differ much from $\frac{1}{3}$ Parts of the same.

From whence it therefore follows, That the Earth's Diameter AB: Is to that of the Moon CD :: As about 11 : To 3; consequently the Body of the Earth is to that of the Moon, as the Cube of 11 or 1331 to the Cube of 3 or 27, according to what we have said about the Sun. And therefore 27 Globes of the Earth are equal to 133 Globes of the Moon, or the Moon is $49\frac{8}{17}$, barely 50 times (to compute in round Numbers) lesser than the Earth.

This Calculation is accurate enough to build upon in Things of such a Nature; and if it be not entirely exact, neither is it far short of the Truth.

With this likewise agrees the Conclusion of that Great Astronomer Mr. Flamsteed, who makes the Diameter of the Earth (as Mr. Whiston says in his *Prælect. Physic.* p. 292.) to amount to 7935 *English* Miles, and that of the Moon 2175 of the same: Which Proportion of 7935 to 2175, varies but little from the abovementioned of 11 to 3.

SECT. XLVII. *Why the Light of the Moon is not Warm.*

Now if we suppose the Point S in the Moon, and the Point B on the Earth, (*Tab. XXI. Fig. 2.*) and farther, the Length Sb as the Moon's Semi-diameter; and if we look back upon what has been said above concerning the diverging and spreading of *Light* at various Distances; as well with respect to its Heat as Shining; we shall find that in both these Cases the Force of the Light at *b*, is to that at B, as the Square of SB, to the Square of Sb.

Now we have shown above, that as SB is $60\frac{1}{2}$ Semi diameters of the Earth, or the Moon's Distance; so Sb is $\frac{1}{11}$ Parts of one Semi-diameter of the Earth, when it represents that of the Moon.

Now $1\frac{1}{11}$ is the Square of $\frac{1}{11}$ or Sb, and $3660\frac{1}{4}$ that of $60\frac{1}{2}$ or SB; and consequently the first is to the second, as 9 to $442890\frac{1}{4}$, or as 1 to 49210, omitting the Fraction. From whence it appears, that the Warmth of the Light which comes down from the Moon, is about 50,000 times less when it has reach'd us upon the Earth B, than it is at the Point *b*, when it has proceeded no farther than the length of one Semi-diameter of the Moon, or Sb.

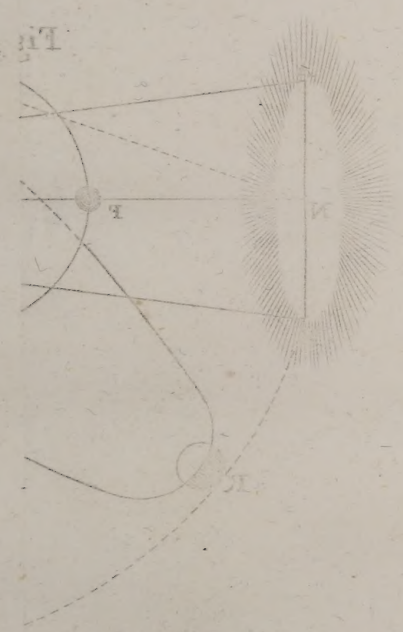
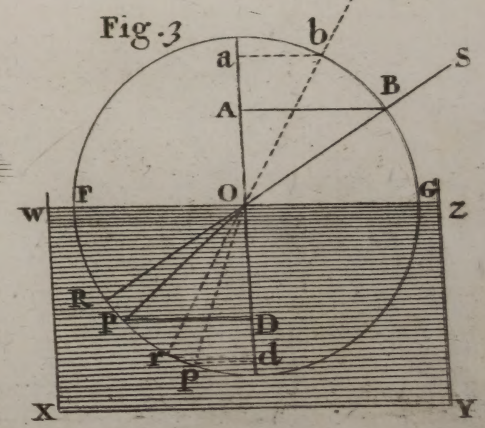
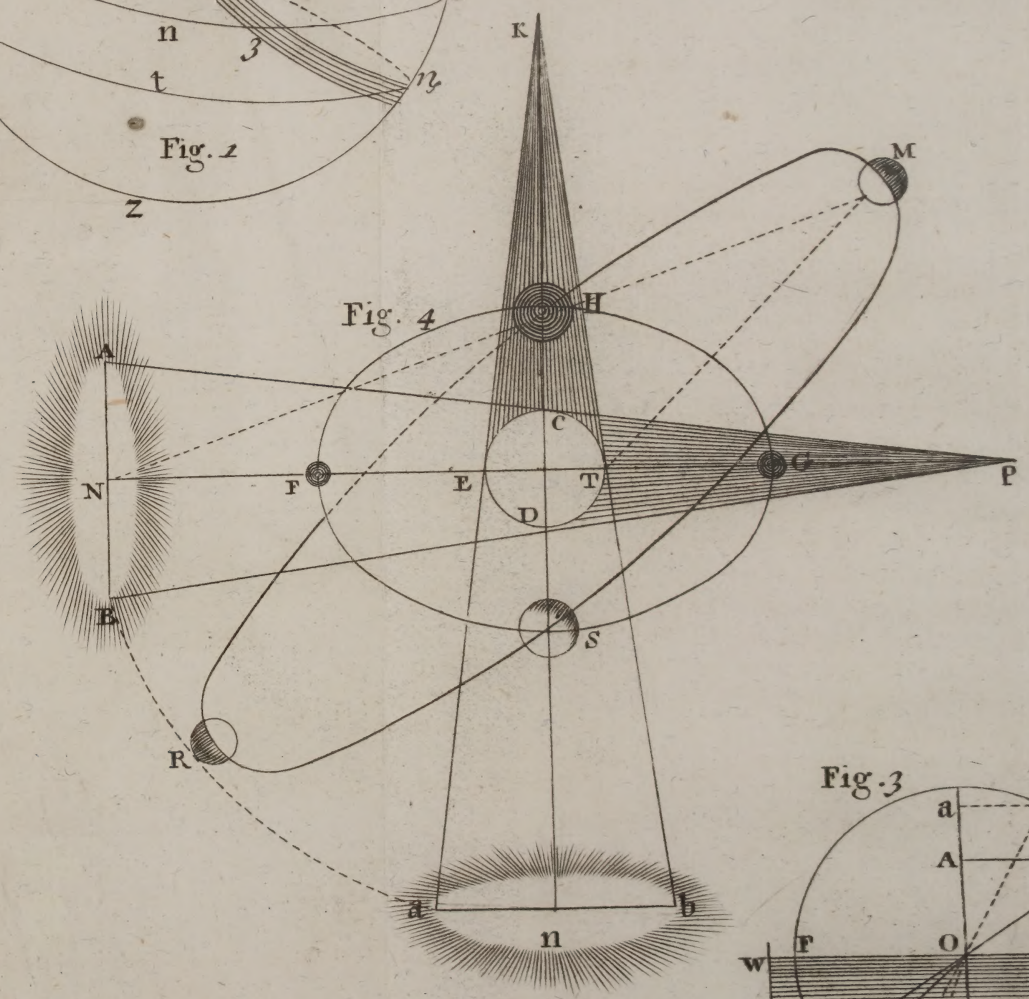
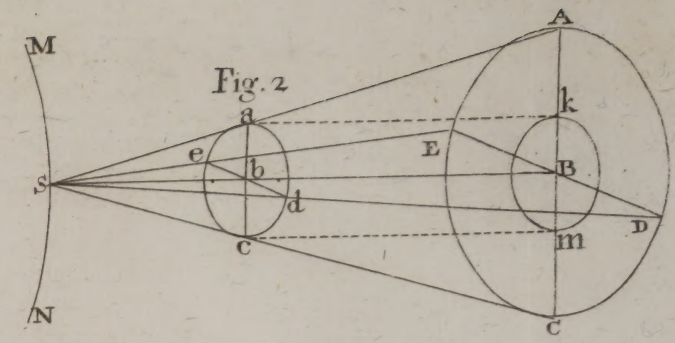
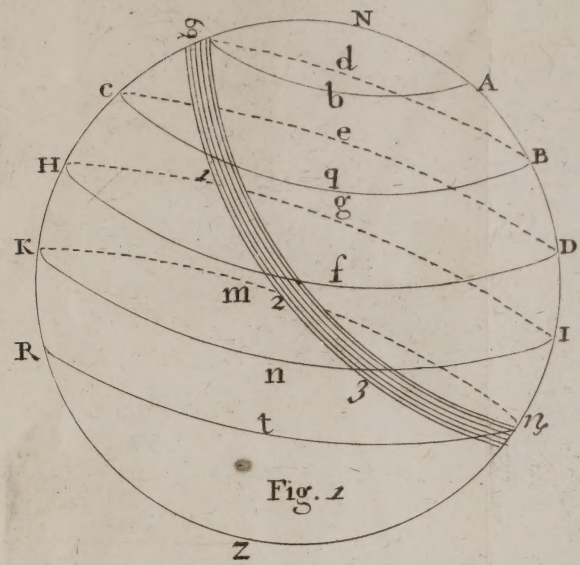
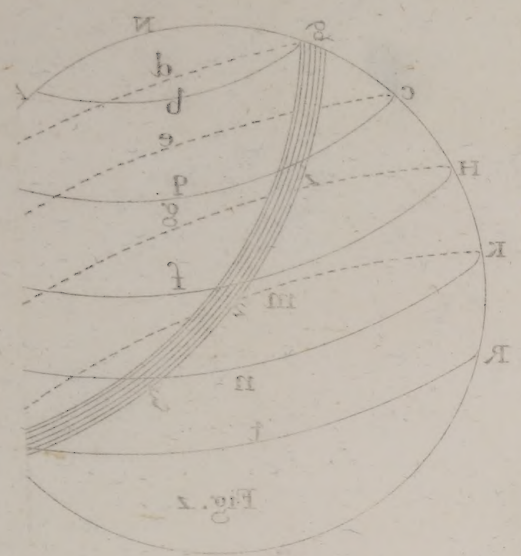
And this is the Reason, according to Mr. *Histon*, *Prælect. Astron.* p. 108. why the Light of the Moon is not attended with any sensible Warmth by the time it has reach'd us here upon Earth. But forasmuch as Dr. *Hook* has collected the same into a Space 500 times smaller, and consequently render'd it 500 times as strong as the said Light is in its natural State; and therefore in such a Focus it is no more than 500 times stronger than at the Moon itself; yet even in that case this Learned Man could not perceive any sign of Warmth, notwithstanding that the Shining, or Light of the Moon (which deserves to be taken Notice of) was increased proportionably. I leave it to the Judgment and Observations of others, whether $\frac{1}{500}$ part of the Warmth of a hot Summers-Day with us, would be able to make any Impression even on the best Thermometer: For that the Rays of the Sun have much the same Power on the Moon, as on the Earth, is plain enough from the little Difference there is of both their Distances from the Sun.

And in this Experiment the Thermometer being moved by the Light of the Sun, it should seem that we are obliged to seek for some other Cause than merely the Distance, to which we should ascribe that the Light or Rays of the Sun are reflected to us from the Moon, without bringing any Heat along with them, but leaving it all behind them.

Be that as it will, this is plain, that if the Moon should transmit to us so much Heat with its Rays, we should suffer many Inconveniencies from thence; which is now prevented by our Great Creator, who directs all Things with infinite Wisdom and Order.

SECT. XLVIII. *The Cause of Ebbing and Flowing not inquired into.*

Now whether the Moon is the Cause of the Ebbing and Flowing of the Great Seas, and of the continual Motions of their Waves to the very bottom thereof, we shall neither dispute nor inquire into here; because we are not yet so far advanced in this Knowledge, as to be able to say any thing concerning





the Point B on the
the Moon's Semi-
axis containing the
half with respect to
the focus of the
orbit of the
the diameter of the
the diameter of the

of the Moon's semi-
axis of the Moon's
the diameter of the
the diameter of the

the diameter of the
the diameter of the
the diameter of the
the diameter of the

the diameter of the
the diameter of the
the diameter of the
the diameter of the

the diameter of the
the diameter of the
the diameter of the
the diameter of the

the diameter of the
the diameter of the
the diameter of the
the diameter of the

the diameter of the
the diameter of the
the diameter of the
the diameter of the

cerning it, that may be free from every ones Objections, tho' we seem to be very far advanced in that Matter.

This is experimentally true, that the Waters in the deep and free Seas (without taking notice here of other Impediments, concurring Causes and Circumstances) rise and swell up to the Places, or about those Places where the Moon is vertical, just as if they were driven thitherward by a Weight, or attracted or pressed by some other Power. Concerning which may be consulted the Writings of *Kepler, Newton, Gregory, Whiston, Varenius, De Stair, &c.*

We find the same happens likewise on the opposite Side of the Earth; wherefore the usual Expressions in which both these Appearances are comprehended, is, that when the Moon passes to the Meridian, the Water rises; when it goes away from thence, it falls. Others say, that it is certain by Observation, that the Water is at highest about three Hours after the Moon has been in the Meridian. See *Newton's Princip. Lib. III. Sect. 24.* and *Whiston Praef. Physic. Math. Sect. 96. p. 306.*

Let this Matter be as it will, it is certainly true by Experience, that if the Earth were cover'd all round with Water, it would appear Oval, by reason of the Swelling of the watry Surfaces on each Side; and these two Protuberances of Water or Mountains, as *Dr. Gregory* terms them, move continually round about the Earth, if they be not obstructed by Land, Shoals or otherwise.

And as for that very ingenious Cause and Figure which *Descartes* produces, and whereby he would shew that it is always ebbing Water upon the Earth directly under the Moon; *Varenius* says in his *Geography, Lib. I. Cap. 14. Sect. 11.* that the same is contrary to Experience, and so it has been found.

However, leaving the Cause to every Man's own Opinion, this is the manner in which we must suppose the Motion of the Sea-Waters to happen, namely, that it is a *Swelling* and *Sinking* of the Sea, rather than a *Flux* or *Reflex*, or *Ebbing* and *Flowing*, according to the vulgar Notion thereof. See concerning the Alteration of these Expressions, *Varenius* in the same Place, *Sect. 10.* and *Gregory Lib. IV. Sect. 65.*

SECT. XLIX. Two Systems of the World.

THERE are two Systems of the Heavenly Bodies, which at present pass for the chiefest, and according to which they are supposed to be moved. The first seems to be the most convenient with respect to the annual Course of the Planets, and is by many taken to be the true one, on account of its Simplicity: 'Tis that which we are wont to ascribe to *Copernicus*, who has revived the same from the Ancients.

They that would form a general Notion thereof, may suppose, (*Tab. XXII. Fig. 1.*) that the Sun stands still, and all the principal Planets move about it, according to the Orbits which they describe in this Figure. D is *Mercury*, the nearest to the Sun; C is *Venus*, next to, and without which follows the Earth A, which upon this Occasion is reckon'd among the Planets, and about which the Moon B runs; E is *Mars*; F *Jupiter*, which has four Moons moving about it, after the same manner as *Saturn* H has five, and it may be six;

and both of 'em carry their respective Moons about with them round the Sun. Beyond all these are the fixed Stars A P O X.

The Second System bears the Name of *Tycho Brahé*, and seems, in relation to the Planets, to be nothing else but the former a little varied in one Case only; and for no other Reason than because that of *Copernicus* supposes the Earth to move about the Sun, and consequently seems to contradict the Scriptures, from which *Tycho* and his Followers make a Scruple of departing.

To understand this System, we must imagine, that the Earth A (*Tab. XXII. Fig. 2.*) stands still, that the Moon B runs round it; that next to it the Sun S describes its Course, and that all the Planets, with their afore-mentioned Moons, bear the same respect to the Sun, as in that of *Copernicus*: So that the Way of each of 'em surrounds the Sun, which continually moves about the Earth; and that all of them must be consider'd as simply moving about the Sun. The fix'd Stars are here likewise represented by A P O X.

In both of 'em there is yet this Difference, that in that of *Copernicus* (*Tab. XXII. Fig. 1.*) the Sun S and the fix'd Stars A P O X, standing as it were still, the Globe of the Earth A really turns round its own Axis, from West to East in 24 Hours, by which Means the whole visible Firmament, Sun, Planet, and Stars seem daily moving from East to West.

In *Tycho's* System, (*Tab. XXII. Fig. 2.*) nothing stands still but the Earth A; whilst all the abovemention'd Bodies are supposed to run round daily from East to West, besides the Course of each in its own Way from West to East. What Reasons may have induced other Astronomers to form one System from these two, I know not; since in that *Semitychonic*, the Simplicity and Convenience of the First, and the Agreement of the Second with the holy Scriptures, seem to be, if not quite lost, at least very much alter'd; for which Reason we shall say nothing of this latter, neither shall we dissuade any one that likes it, from embracing it, since we don't here undertake to dispute the Truth thereof, but endeavour to represent to Sceptical Philosophers, so much as we know to be true of it from Experience and unquestionable Calculations, in hope to convince them thereby that there is a GOD.

SECT. L. *The Immensurable Magnitude of the Fix'd Stars.*

To come then to the Matter: Let those who still doubt of a Powerful and Wise GOD, lift up their Eyes with us, and suppose this to be the first Time of their Life that they ever saw the Heavens adorned with so many glorious Lights; and tell us, whether they should not be thereby convinced that the same had a Mighty Creator, and that it was not by mere Chance that they had acquired their Origin and Lustre, no more than a Locket set with Diamonds, of which the most obdurate Atheist would not dare to affirm, that they were put together without the Skill of an Artificer; much less would they affirm it of the Heavens, especially if they observe the immensurable Magnitude thereof, which is such, that the Astronomers have not been able hitherto to communicate any thing to us that can be more depended on than mere Conjecture; nor have they been able to answer all

all the Questions concerning the Magnitude and Distance of the Fix'd Stars.

Thus we hear the great Observer of the Heavens, Mr. *Huygens*, in his *Cosmotheoros*, p. 135. ingenuously acknowledging the same in the following Expressions: *But those who before us have endeavour'd to determine this immense Space, have not been able to conceive any thing certain, by reason of the great Exactness necessarily requisite in the Observations, and which exceeded the utmost Care and Diligence; for which reason, the Method I have now chosen, seems to be the only one remaining, in order to attain to something that might be at least probable in a Matter of such difficult Inquiry: Of which he gives the Reason a few Lines after, in this manner: The Stars also of the first Magnitude, tho' view'd even by a Telescope, appear all so little, that one would take 'em for little lighted Matches without any Breadth, which is the Cause that no Measure of their Bigness can be found out by this sort of Observation.*

It will not be necessary to produce any other of the modern Mathematicians who are of the same Opinion, after the Testimony of an Astronomer, to whom the utmost Efforts of all the famous Men of Learning were well known, he being a Member of the *Royal French Academy*, and not only in himself a Discoverer of new and never before seen Lights and Phenomena in the Heavens, but likewise of an indifatigable Zeal, and abundantly blessed with a temporal Estate, whereby he was enabled to make Experiments of all Things.

The Method which that great Philosopher took, in order to form some probable Conjectures concerning the Distance of the Stars, supposes however, that which has no certain Foundation, namely, That a Star (at least one of the first Magnitude, such as *Syrius*, or the *Great Dog-Star*) is as big as the Sun; from whence he infers, That the Distance of the Stars from the Earth is 27,664 times greater than that of the Sun from the said Earth: See his *Cosmotheoros*, p. 137. notwithstanding that he allows this last to be above 12,000 whole Diameters of the Earth.

SECT. LI. *Of the Parallax of the Fix'd Stars.*

ANOTHER Method of inquiring into this Distance with greater Certainty (if the Event had been favourable) has been some Years since set on foot by Messieurs *Flamsteed* and *Hook*, who thought that they could deduce from their Experiments, that the Diameter of the Earth's Way about the Sun (according to *Copernicus*) made some Alteration of Sight with respect to the fix'd Stars, in Proportion as the Earth was so much nearer, or so much farther from them; whereby likewise the System of *Copernicus* of the Earth's Motion, seemed to be proved at the same time. I shall not here rehearse the differing Notions of *Gregory*, *Whiston*, and others about the same; but that from these Observations, even tho' they were true, the Distance of the Stars and Motion of the Earth cannot be proved, is sufficiently shewn by Mr. *Cassini*, in the *History of the French Academy* for the Year 1699.

So that these two last Methods, in which all imaginable Helps, known to the Moderns, are used, leaving the Matter still uncertain, there is no great

Hopes of meeting any better, at least since the Globe of the Earth is no bigger, or (according to *Copernicus*) its Way about the Sun of a larger Diameter, that it may the better serve for a Foundation for measuring such a Distance. Now as long as the Distance of the fixed Stars from the Sun or from the Earth remains unmeasurable, it follows from thence, that the Magnitude of the Starry Heavens, tho' one were to consider it as an Orb about the Sun or Earth, which cannot yet be proved from Nature, will always remain likewise immensurable.

Now that the Holy Scriptures speak here according to the strictest Truth, as they do likewise about many other Things of Nature, every Man must own, who will consider that Passage in *Proverbs* xxv. 3. *The Heaven for Height, and the Earth for Depth, and the Heart of Kings is unsearchable.* In like manner, when the said Scriptures would propose any Thing which surpasses all Mens Conception, they compare it with the Height of Heaven, as in *Pf. ciii.* 11. *As the Heaven is high above the Earth, so great is his Mercy towards them that fear him.* But the Expression of the Prophet *Jeremiah* is yet more full and emphatical, ch. xxxi. v. 37 *If Heaven above can be measured, and the Foundations of the Earth searched out beneath, I will also cast off all the Seed of Israel—* From whence we may plainly enough infer, that since GOD was not pleased to cast off all the Seed of *Israel*, in which the Saviour of the World was comprised, as he expressly says, so neither is Heaven or the Firmament capable of being measured.

Let me now ask an Infidel, whether or no he does not here discover the Divinity of the Holy Writ? For unless He who dictated it were an omniscient GOD, and did know all the Counsels of Men, and even the Issues thereof to the End of Ages, how can it be imagined, that an Author of any Sense would venture positively to advance such an Assertion as this, concerning the Immensity of the Heavens; which, (notwithstanding the Zeal and restless Attempts of all Sorts of Men; notwithstanding the Charges and Expences bestowed by such great Potentates wholly and solely in this Inquiry; notwithstanding that Diligence whereby other Matters, which at first seem incredible, have been at length found out) remains good, even after so many Ages, to this Day; so far as much as Heaven continues as much immensurable as ever.

It did indeed seem very probable to Philosophers, that a Method might in time be found to measure not only the starry Heaven, but even the Stars themselves; when first great Mathematicians found a Means in *Astronomy* to make use of the Orb of the Earth (or the Orb of the Sun) as an Instrument to measure Angles; and by their Pendulums, and Micrometers (as they call them) plac'd in the Focus of great Telescopes, became able to measure Angles in the Heavens, even to Seconds, or 60th Parts of a Minute: Whereas before, with the most costly and cumbersome Instruments, *Astronomers* cou'd hardly measure to whole Minutes with any Certainty.

Nay, and what is more remarkable, is, that farther Discoveries should be obstructed by the following Phenomenon; namely, that whereas all other enlightned Objects are magnified by Telescopes (the *Astronomers* principal Instru-

Instruments) the fixed Stars seen thro' them appear less than when seen with the naked Eye, and therefore can be of no Use in measuring the starry Heaven, as it might have been expected. When the Planets, which to the naked Eye appear no bigger than the fixed Stars, by means of the Telescope appear very large and distinct.

I am sensible that the Reason given for the Appearance is, that the Telescopes take off the spurious Rays that accompany the fixed Stars; neither do I now dispute it, tho' the spurious Rays that make *Venus* twinkle, being taken by a Telescope with a small Aperture, that Planet still appears bigger. However, notwithstanding all this, it is certainly true, that in this Case the Telescope has an Effect quite different from what it has in other Cases. Concerning this, see Dr. *Gregory's Astronomy*, and other Authors, whereby it will appear that the Distance of the starry Heaven is not to be measur'd by any Mortal. So that this Word pronounc'd by the Creator, namely, *that the Firmament is unmeasurable*, continues in full Force, and shews the divine Original of the Heavens; thereby, as it were, setting Bounds to the Labours of the following Ages, and giving Limits to *Astronomy*.

SECT. LII. *Whether the Starry Firmament be Solid or Fluid.*

NOW since such great Mathematicians have with so much Ingenuity owned themselves unable to measure the so vastly extended Magnitude of the starry Heavens, which does in a manner surpass all human Imagination; how great Progress had there been perhaps made in the Science of Nature, if the Philosophers had behaved after the same manner, with respect to the Matter and Figure of which this starry Heaven consists, and if they had made the best use of that Time which young Learners employ in uncertain Conjectures and Hypotheses, without any Foundation, in making new and material Observations? Since it remains a Mystery to the greatest Astronomers, how the heavenly Bodies are framed and constituted. *Descartes* supposes 'em to consist of fluid *Vortices*, as is well known. Sir *Isaac Newton*, in his *Scholium* to the 53 *Proposition* in the *Third Book*, shews the contrary; and farther subjoins, that this Hypothesis is inconsistent with all Astronomical Appearances; concerning which Mr. *Huygens* may likewise be consulted in his *Cosmotheoros*, from p. 139 quite to the End, and in other Places, not to mention any more.

SECT. LIII. *Probable Reasons for its being Solid.*

THE Foundation of these Opinions, that the Heavens are a solid Body, is principally, that the Distance of the Stars from each other, has remain'd in a manner the same without any Alteration for so many Ages, which seems more agreeable to the Nature of a solid Matter, in which they are supposed to be placed, than in a Fluid.

THIS Conclusion seems likewise to be made with some kind of Probability, from the wonderful Observation related by Mr. *Huygens* in his *Syst. Saturni*. p. 8, and 9. and which we don't know to have been taken Notice of by any one before: His Words are as follows: "Astronomers place three
"Stars

“ Stars close to each other in the *Sword of Orion*; and when I view’d the middlemost with a Telescope, in the Year 1656, there appeared in the Place of that one (which is no new thing) twelve other Stars, after the manner as they are represented in *Tab. XXIII. Fig. 1.* Among these, three that do almost touch each other, and four more besides, appeared twinkling as thro’ a Fogg; so that the Space about ’em seemed much brighter and lighter than the rest of the Heavens, which appearing wholly blackish, by reason of the fair Weather, was seen as through a certain Opening and Separation, thro’ which one had a free View into another Region that was more enlighten’d. I have often observed the very same thing with this, without any Alteration, and in the same Place; so that it is likely that this Wonder, whatever it may be in it self, has been there from all Times; but I never took Notice of any thing like it among the rest of the fix’d Stars; for we do not find that the others, which were formerly accounted cloudy (*Nebulosa*) nor the Milky-Way itself, have any Mist or Vapour about ’em; nor if we view them with a Telescope, do they appear to be any thing else than a Collection of many small Stars.

Now I leave it to the Judgment of an impartial Person, whether one has not more Reason, from these Experiments, to believe that the starry Heavens do rather consist of a solid Matter than a Flood of Particles continually moving among each other; since the aforesaid enlighten’d Opening shews itself always circumscribed after the same manner; which in fluid Matters, that are so susceptible of Motion, can hardly be expected.

SECT. LIV. *The amazing Greatness and Distance of the Stars.*

Now to proceed: As this great visible Firmament is immensurable, on account of the almost inconceivable Extent of the Distance thereof, so likewise must we look upon the Remoteness of the Stars, and the Magnitude of those Bodies, as things incapable of being determined by Men: The Reason is, because the Diameter of the Earth is to that of a fixed Star, as the horizontal *Parallax* is to the apparent Diameter of the same. Now it is plain by Experience, that the Earth, and even according to *Copernicus*, the Diameter of that whole Circuit which it makes about the Sun, must be consider’d only as a Point, with respect to the Distance of the Stars, and much too small to produce any *Parallax*. Besides, we likewise find, that the best Telescopes that are made, can only represent the said Stars as so many Points of Needles, and without Breadth, insomuch that we can’t discover any Measure of the apparent Diameters thereof by the Help of those Instruments; so that from the Impossibility of observing the *Parallax*, and especially the apparent Diameter, we are entirely disabled from determining the Magnitude of those Stars.

Now whether, with the modern Astronomers, we are to consider every one of those Stars, at least all those of the first Magnitude, such as the *Dog-Star*, and the like, as so many Suns, both in Splendor and Bigness, has not yet yet been proved by any one: This is certain, that they are immeasurably remote from us, and that in so unconceivable a Distance they derive a

Native Light down to us; as also, that if the Sun were as far from us, it would not appear bigger than one of those Stars.

If therefore, without insisting upon a real Proof, we suppose those Stars to be so many Suns from the Strength of their Light, and from their great Distance (in which we do but follow, if not all, at least the greatest Astronomers) we shall have an Idea of the heavenly Bodies that includes in it an amazing Greatness.

According to this manner, the Conjectures of Mr. *Huygens* will not appear ill grounded, who, upon the Calculation laid down in his *Cosmotheoros*, p. 136, and 137. makes the Distance of the fix'd Stars from the Earth 27,664 times greater than that of the Sun. So that if, according to what we have said before, a Cannon Bullet will require 26 Years in passing from hence to the Sun with the same Velocity wherewith it was discharged, it would require, in order to arrive at the fix'd Stars, 25 times 27,664, that is, 691,600, or almost seven hundred thousand Years; and a Ship that can sail 50 Miles in a Day and a Night, will require 30.430,400 Years. And if we proceed further upon this same Foundation, and suppose with those Gentlemen, that each Star has a Space about it proportionable to that of the Sun, I leave every Man to judge, whether he be able, without a great deal of Pains, to form to himself a just Idea of this wonderful Extent of the Universe, and whether he be not in danger of losing himself in the Contemplation of so unconceivable a Greatness of so glorious a Structure, in which the Footsteps of the divine Builder do so manifestly appear. I have chose rather to make use of this Hypothesis of Mr. *Huygens* preferable to others, because nothing else is maintain'd by him, than that one of those great Stars are like the Sun; and that the Splendor and Light of the Sun, when its Diameter is contracted according to the aforesaid Proportion, will be only equal to that of the *Dog-Star*: but whether this be true or no, yet it is beyond all Doubt that the fix'd Stars are very great, and that their Greatness and Distance is not to be determined, since the manner of inquiring into it can hardly be carried farther, according to the Opinion of great Mathematicians: See *Gregory, Schol. Prop. 55. Lib 3.*

SECT. LV. *Convictions from the foregoing Observations.*

I HAVE oftentimes most seriously reflect'd upon this Impossibility of determining the Magnitude and Distance of the Stars as an Effect of the adorable Wisdom of their Great Creator; who knowing, that if they were capable of being measured, how great soever the Extent thereof might be, yet from the Habitude and Custom of mentioning the same, the Wonderfulness thereof would be much diminished: He therefore thought it necessary to make them immensurable, and to put them out of the Reach of all human Endeavours, and likewise, to the end that those who despise Him might be forced in Spight of all their kicking against it, to confess a Power to which they could set no Bounds; and since all their Learning could never fathom it, to live in a continual Astonishment at it, as it happens most commonly in relation to things that pass our Understanding.

SECT. LVI, and LVII. *The Stars numberless, and Convictions from thence.*

AT least the Divine Authority of the holy Scriptures is evident from hence, by which, even from the first Ages of the World, the Magnitude of the Stars are determin'd to be absolutely inscrutable, and consequently shewn even then where the Efforts of Men in following Ages should find their Bounds, notwithstanding their utmost Endeavours to the contrary. The Places upon which we have our Eye on this Occasion, are the Words of *Job*, chap. ix. ver. 9, 10. where having first said of the fixed Stars in the 9th Verse, *which maketh Arcturus, Orion, and Pleiades, and the Chambers of the South*, he continues in the 10th Verse to say, *which doeth great things past finding out, yea, and Wonders without number*. From whence not only what has been said before, of the Inscrutability of the Stars Magnitude may be inferr'd, but likewise, in order to prove the infinite Knowledge of that Spirit, by whose Inspiration this Word is written, more plainly against all Unbelievers, we find it likewise literally expressed, that those Stars are not to be number'd; which could not have been irrefragably proved before our Times against any one that would have denied the same. Besides the above-quoted Text, this Innumerability of the Stars has been likewise asserted in several other Places of Scripture: Thus God says to *Abraham*, in *Gen. xv. 5*. *Look now toward Heaven, and tell the Stars, if thou be able to number them: and he said unto him, so shall thy Seed be*. And the Almighty does frequently make use of the same Comparison to express the infinite Number of the Children of *Israel*, viz. *Exod. xxxii. 13*. *Deut. i. 10*. — *x. 22*. — *xxviii. 62*. *Neh. ix. 23*. and several others; besides that these thousands of *Israelites* are oftentimes compared likewise with the Sand of the Sea, as in *Isaiah x. 22*. *Hosea i. 10*, &c from whence it appears at the same time, that the Number of the Stars is not only made as great, but likewise as innumerable as the Sands of the Sea, in the said Holy Scriptures.

Now it is known to all Astronomers, that in order to pronounce such a great Number of Stars innumerable, or to compare the Number of *Abraham's* Children thereto, they could not be seen in the Heavens whilst they had no use of Telescopes.

Hipparchus, in his Catalogues of Stars, has transmitted to Posterity the Number of 1026; which in our Age has been increased to 1888, by the great Astronomer *Hevelius*; among which are to be reckon'd 950 that were known to the Ancients, 603 which he calls his, and 335 observed by *Dr. Halley* in the Southern Parts of the Heavens, of which *Dr. Gregory* treats more largely, *Lib. XI. Sect. 29*. but after that the Telescopes had discover'd that the great broad white Streak extending itself round the whole Heavens, and which, upon the Account of its Whiteness, they call the *Milky-Way*, was formed of a Collection of numberless little Stars, which *Dr. Halley* likewise testifies of the *Southern Magellanic Little Clouds*: See *Gregory, Lib. XI. Sect. 22*. After that, as it appears from the afore-cited Place of *Mr. Huygens*, for one Star that we see with our naked Eyes, several others offer themselves to the Telescope; so that according to the Remarks of *Cherubin d'Orleans*, p. 270, and 313, by the Help of the same, only in the Constellation of *Orion*, more

Stars,

Stars, and according to the Observations of *Rheita*, related by *Zahn*, Fund: III. p. 209. twice as many shew themselves, as are seen by the Eye only in the whole Heavens: I say, since these Telescopical Observations, Astronomers have lost all Hopes of ever fixing the exact Number of the Stars, the rather, because the more those Telescopes are improved, the greater Number of Stars are seen; insomuch, that some, tho' without Foundation, have maintained, that the Number of the Stars is infinite, as Mr. *Huygens* witnesses of *Jordanus Brunus* in his *Cosmotheoros*, p. 138; but to say nothing more than what is true, this is certain, that the modern Observations made by the help of these Instruments, do sufficiently evince that the Stars are not to be counted. See *Whiston. Praelect. Astron.* p. 23.

Now let an Infidel tell us how it is that *Moses* and *Job*, if they had not been divinely inspired, could in their Times have pronounced the Stars to be innumerable, since it was so many Ages after, that this excessive Multitude, upon the Discovery of Telescopes, has been experimentally known to Mankind.

SECT. LVIII. *Whether the Stars differ in Magnitude.*

Now if we inquire into the Opinions of the greatest Mathematicians concerning the Difference of Stars from one another, we find the most able of 'em ingenuously confessing, that it is perfectly unknown to them, whether all the Stars are of equal bigness; insomuch that it is doubtful whether some of 'em appear smaller only upon the Account of their being farther distant from the Eye, or whether one Star is really bigger than another.

The Apostle *Paul* does positively determine the Matter in these Words, I Cor. xv. 41. *One Star differeth from another Star in Glory*; and if I may be allowed to add something by which that Saying of the Apostle seems to be verified in some manner from Nature, I desire the Reader to consider with himself, whether it be not more credible, that one Star is bigger than another, than that they should all be of the same Bigness, and at different Distances; since we find by the Observations of the greatest Astronomers, that it is certain enough that some Stars have plainly altered their Magnitude, and become smaller: (See an Account thereof in *Gregory, Lib. II. Sect. 30.*) for I cannot believe that any body will ascribe this only and entirely to their removing to a greater Distance. Yet if such a thing could happen, he may be pleased to pass this Reflection by, tho' otherwise the different Magnitude of the Planets seems in some manner to lead to such an Opinion.

SECT. LIX. *Alterations in the Fixed Stars.*

BEFORE I proceed any farther, I cannot forbear, upon occasion of what we have already mentioned, to say something of what has been observed in the Heavens, with respect to the Stars, about an Age ago, and which has astonished all the Astronomers. Mr. *Whiston* in his *Praelect. Astron.* p. 47. names it a very great and astonishing Wonder, that must be transmitted or left to following Ages, without our being able to give any Solution thereof.

That which is meant here, are those Alterations among the fixed Stars; that are still unintelligible to us, whereby we find that some new ones appear, and others that have been seen, do disappear; and a third sort shew themselves one time with more, and another time with a lesser Lustre. *Hipparchus* is said to have observed one; but in the Year 1572, we know that a new one appeared in the *Chair of Cassiopea*; in 1600, in the *Breast of the Swan*; in 1604, in the *right Heel of the Serpentarius*; and several others may be found in *Gregory, Lib. II. Sect. 30.* as also in *Mercator and Whiston*, that give us an Account of them and their Number. Some again, that had been seen before, are now invisible; and *Hevelius* says, in his *Præcursor*, that they sought in vain for five Stars, whose Places however *Tycho Brahé* had described full an Age before: Concerning which, the said *Gregory* gives us a farther Account in the *Act. Lips. 1691. p. 80.* as also how a Star belonging to the *Neck of the Whale* has often disappeared, and shewn itself again in the same Place at different times; See *Act. Lips. 1703. p. 213.* and how their Magnitude is remarkably changed in others, at least with respect to their Light. The Reader may likewise note what has been mention'd concerning *Kirchius* in the *aforesaid Transactions of Leipsick, 1687. p. 647,* since we cannot stand here to reckon up all those Particulars.

SECT. LX. Concerning the Planets.

LET us now proceed to the Planets, or Wandering Stars, so called, because they appear to us who live upon the Earth A, (*Tab. XXII. Fig. 1, and 2.*) to move sometimes quick, other times slow; now forwards, then backwards, and another while to stand still for a time; which, to those that have not inquired into their Courses, looks like *Wandering*; tho' those that do understand it, know, that with respect to the Sun they only proceed forwards, but yet occasion the same Appearances, for which the Astronomers have accounted.

All the Planets, as we have said before, do move about the Sun S: But two, which are therefore stiled the lowest, viz, *Mercury D*, and *Venus C*, perform their Revolution in such a manner, that as they are seen from the Earth, they appear always on the same side with the Sun: Whereas the three other, *Mars E*, *Jupiter F*, *Saturn H*, are seen from the Earth A, sometimes on the same side, and sometimes on the opposite side of the Sun, as you may observe on the abovemention'd two Figures of this Table.

Now in order to form a right Notion of these Planets, we must again endeavour to divest ourselves of those Prejudices which we have suck'd in as it were with our Mother's Milk, and by which we are taught to imagine that these great Bodies are about the size of the Marbles we play'd with when we were Children, or somewhat less, and that they are but a very small Distance from us; and we are yet the more confirmed in the same, by the Figures that Astronomers are wont to give us of these Planets, which at the best do represent to us the Proportion of their Distances but in a very small Compass, and do rarely or never shew us their Bodies in comparison of their real Magnitudes, which likewise considerably helps to hinder us from forming a right Conception of their true Magnitudes.

SECT. LXI. *The Magnitude of the Planets.*

THAT famous Astronomer Mr. *Huygens*, in order to improve our Notions concerning the Planets, did at the latter end of his Life draw their Magnitudes in a particular Figure in proportion to that of the Sun, which we have therefore transferr'd from his *Autom. Planet.* to our *Tab. XXIII. Fig. 2.* where the Earth A, and the Moon by it at B, and so the rest of the Planets are represented in their proportionable Bignesses with respect to the Sun G D K. According to his Observations we find the Diameter of the Sun to be,

110	times greater than that of the Earth	A.
308	_____ than that of Mercury	D.
84	_____ than that of Venus	C.
166	_____ than that of Mars	E.
$5\frac{1}{2}$	_____ than that of Jupiter	F.
$3\frac{1}{17}$	_____ than that of Saturn's Ring	G I.

and that of the Ring $2\frac{1}{4}$ times bigger than the Diameter of the Globe of Saturn H.

From whence it follows, if these Planets are compared with the Earth, which is best known to us,

I. That the Earth is not quite 3 times so thick, and consequently not quite 27 times as big as the Planet Mercury D.

II. That Venus C is about $1\frac{1}{3}$ as thick, and consequently as big as the Earth it self.

III. That Mars E, is smaller than the Earth, so that the Diameter of the latter will make $1\frac{1}{3}$ of the former, and consequently contains $3\frac{1}{8}$ as much Matter as the Globe of Mars.

IV. That Jupiter F, has 20 times as great a Diameter, and 8000 times as large a Bulk as that of the Earth.

It has likewise four Satellites or Moons about it, each of which does not seem lesser than the whole Earth: See *Huygens Cosm.* p. 101.

V. After these comes Saturn H, which, (what no Body could ever have thought or suspected) is surrounded with a Ring G I, that is flat and very thin in proportion to its Magnitude: There is a Space between that Ring and the Body of the Planet, which it encompasses without any Contiguity, like a Vault or Ceiling; for which Reason this Disposition of Saturn with its Ring, being viewed from different Parts of the Earth, is wont to represent a very different Figure. The Diameter of this Ring G I, is, according to the foregoing Computation, about 30 times as large as the Diameter of the Earth; and therefore if it were a Globe, it would contain about 27,000 times the quantity of this Globe of the Earth.

The Diameter of Saturn itself is about 13 times as big as the Earth's, and consequently the Body of that Planet is 2197 times as large as the whole Earth; besides which there are five Moons that are observed to circulate about the said Planet and its Ring.

SECT. LXII. *The Times of the Planets Revolutions and Distances from the Sun.*

NOW the Times in which these Planets finish their respective Circulations about the Sun, have been observed as follows: That of *Mercury*, in three Months; of *Venus*, in about $7\frac{1}{2}$ Months; of *Mars*, in almost two Years; of *Jupiter* in 12 Years; and that of *Saturn*, in about 30 Years, all of 'em computed as near as may be.

We shall here pass by the *Satellites*; they who desire to know the Time of their Revolutions about *Jupiter* and *Saturn*, may consult the Astronomers.

The Distances of these Planets from the Sun are likewise reckoned in the following manner: Upon the Supposition that the Distance of the Earth from the Sun is 10, that of *Mercury* is hardly 4, *Venus* 7, *Mars* 15, *Jupiter* 51, and *Saturn* 95 of the same Parts: See *Gregory Astron. Lib. 1. Sect. 1.* So that the Distance of our Earth from the Sun being, according to *Cassini* and *Flamsteed*, (for the more convenient Calculation) 10000 Diameters of the Earth; *Mercury* will be 4000; *Venus* 7000; *Mars* 15000; *Jupiter* 51000; and *Saturn* 95000; and proportionably so much greater, if with *Mr. Huygens* we account the Distance of the Sun to be 12000, or with *Mr. la Hire* 17000 of the said Diameters. We have here used the smallest Numbers, because we would proceed with the greater Certainty.

SECT. LXIII. *The Velocity of Venus and Jupiter.*

NOW let the Atheist consider, that notwithstanding the contemptible Notions he has of these heavenly Bodies, which he looks upon as no bigger than they are represented in *Tab. XXII. Fig. 1, and 2*; and in *Tab. XXIII. Fig. 2.* yet *Venus*, the Evening and Morning Star, is a Globe not much smaller than that of the Earth; and, which is amazing, it moves about the Sun with a Swiftneſs 146 times greater than that of a Bullet shot out of a Cannon. To give likewise an Instance of one of the remotest Planets, let him contemplate that of *Jupiter*, which is a Globe 8000 times as big as this of the Earth; and let him consider, *First*, how great a Distance it must be from him, when so vast a Body shall appear as small as one of our Childrens Marbles: And, *Secondly*, what a Force is necessary to move such a prodigious Globe along the Heavens, the Motion of which we find to be 54 times swifter than a Cannon-Bullet's.

SECT. LXIV. *The Calculation of the Revolutions of the aforesaid Planets.*

THIS may perhaps seem somewhat whimsical and incredible too to ignorant Persons; but those who understand Astronomy, know that nothing need be advanced by Conjecture or Guessing, when one compares the Magnitude and Distance of the Planets with that of the Sun; but that the same may be deduced by certain Consequences from the Observations that have been made concerning them, as every Mathematician knows, and as literally appears in the *Syst. Saturn.* p. 77 and 81, of *Mr. Huygens*; so that upon the whole Matter, it depends only on the Greatness and Distance of the Earth with respect to the Sun, not to know the Proportion only, but the true

true Measure thereof, of which Astronomers are in a manner so much Masters, that they can be sure that neither the Planets themselves nor their Distances are supposed too great.

If it be then known that there is no Mistake of any Importance made herein, the swiftness of their Motion may be easily computed from the time of their Revolution: As for Instance, a Cannon-Bullet runs, according to the Experiments of *Mersennus*, (quoted by *Huygens* in his *Cosmotheoros*, p.125.) 100 *French Toises* of six Foot each, in the space of a Second; and according to the most accurate Measuring of the *French*, the Diameter of the Earth amounts to 6,538,594 of the said *Toises*, or Fathoms.

Accordingly then a Cannon-Bullet would run the length of the Earth's Diameter in about 65,386 Seconds, that is, full 18 Hours; from whence it follows, that it would run in one Year, consisting of 365 Days, 486 of the like Diameters, and 40 thereof in a Month of 30 Days.

Now it appears above, that (*Tab. XXII. Fig. 1 and 2.*) the length between the Sun and Earth, or the Line AS, being supposed to be 10,000 Diameters (which is less than what is allowed by Mess. *Huygens* and *la Hire*) the Distance of *Venus* from the Sun, or the Line SC, will amount to 7000 of the said Diameters; and if now we take the Revolution CIR for a Circle, of which CS is the half Diameter, the whole one CR will be 14000 of the Earth's Diameters; and supposing the Ratio of the whole Diameter to the Circumference of a Circle, according to what is known, as 113 to 355; the Circumference CIR of this Diameter CR, which *Venus* finishes in $7\frac{1}{2}$ Months, will be 43,982 Diameters of the Earth.

But it is found before, that a Bullet runs 300 of the like Diameters in $7\frac{1}{2}$ Months, or in the time of *Venus*'s Revolution. Thus it appears, that the Velocity of *Venus*, with respect to that of a Cannon-Bullet is as 43,982 to 300, or that *Venus* moves 146 times faster than the said Bullet.

After the like manner, and with very little Trouble too, we may compute, that since *Jupiter*'s Distance from the Sun, or the Semidiameter of its Way (supposing it likewise to be exactly circular) amounts to 51,000 Diameters of the Earth, and that the Time of its Revolution is 12 Years; it moves about 55 times, at least a good deal above 54 faster than a Cannon-Bullet, that shall run in one Year 486 of the like Diameters, as has been shewn above. We suppose here the Courses of the Planets to be uniform, though Astronomers find that they move one while faster, and another slower; but forasmuch as they perform their Revolutions in about the said time, this Calculation is certain enough.

SECT. LXV. The Swiftness of one of *Jupiter*'s Moons.

IF we now suppose with Mr. *Cassini*, (See the *Cosmotheoros*, p. 101.) that the nearest of *Jupiter*'s Moons is distant from it $2\frac{1}{2}$ Diameters of that Planet, and that its Revolution is performed in one Day, eighteen Hours, twenty eight Minutes, and thirty six Seconds; the whole Diameter of the said Revolution, will be $5\frac{2}{3}$, and the Circumference, supposing it to be exactly circular, will be $17\frac{7}{39}$ Diameters of *Jupiter*.

Now

Now one Diameter of *Jupiter* is equal to 20 Diameters of the Earth; the Revolution therefore of this nearest Moon is 356 of the said Diameters; and according to the supposed Time of the Revolution, this runs in one Day in its Way about *Jupiter*, 201 Diameters of the Earth; and *Jupiter*, according to its before-supposed Distance and Time of its Revolution, runs 73 Diameters in its Orbit about the Sun in the said Space of a Day; so that this Moon runs in its Orbit about twice or thrice as fast as *Jupiter* itself, and consequently a great deal above 100 times faster than a Cannon-Bullet, tho' it be as big as the Earth itself: See *Huygen's Cosmotheros*, p. 101.

SECT. LXVI. *The amazing Force that is requisite to move Jupiter.*

Now if one would form an Idea of the amazing Greatness of that Power by which the said Planet is moved, it having been proved before that the Diameter of *Jupiter* is 20 times greater than that of the Earth, it follows that the former Planet is 8000 times bigger than the latter.

Now those who understand Mechanicks know, that by multiplying the Mass of two Bodies, each of 'em by its own Velocity, the Proportion of the Powers that move them, may be learned from thence: Supposing then that the Earth's Magnitude to be as an Unit, and the Velocity of the Cannon-Bullet to be likewise as an Unit, the Force that must move the Earth with the same Swiftmess as a Cannon-Bullet is moved, must also be as an Unit, because an Unit multiplied by itself, produces only an Unit.

And in this Comparison the Globe of *Jupiter* must be supposed as 8000, and its Velocity as 54, because it moves in its Orbit 54 times swifter than a Bullet; which being multiplied with the other, gives 432,000 for the Force that moves *Jupiter*.

So that it is irrefragably proved hereby, that the Force which moves *Jupiter*, and consequently the Strength of the Planet itself, is at least 432,000 times as great as that which is capable of causing the Earth to move with the same Velocity as a Bullet is discharged from a Cannon.

We suppose here the Density of the Parts of which the Earth and *Jupiter* are composed to be equal; tho' some reckon that of the Earth to be greater than *Jupiter's*; yet this Difference will not hinder the said Number from remaining a great many Thousand Times more; but this is not the Place to make so nice an Enquiry in.

SECT. LXVII. *Convictions from the Whole.*

Now they that hitherto doubt whether there be a mighty Creator and Director of this Universe, let them sit down by themselves, and seriously consider, *First*, How these Planetary Globes, so amazing in their Magnitudes, are whirl'd about the Sun with so dreadful a Velocity, so far surpassing the almost unconceivable Motion of a Cannon-Bullet.

Secondly, How other Planets, or Moons, each of which will hardly yield in Magnitude to the Earth, are carried with a yet greater Swiftmess about the aforesaid Planets.

Thirdly,

Thirdly, That neither the Motion of *Jupiter* in his Orbit, nor of the rest of the Planets, can be performed but by a Force so many thousand times greater than that mighty Strength by which a Globe as large as the whole Earth is driven with the same Velocity as a Bullet shot out of a Cannon.

And if this last Force, whereby the Earth can be so swiftly moved, surpasses all human Conception, what shall we say of that which moves the Planet *Jupiter* in the Heavens?

SECT. LXVIII. *The Evasions of Atheists, and their Pretences.*

I KNOW very well, that in order to elude the Proof of an All-ruling God, which is so terrible to Atheists, those miserable Wretches are wont to conceive the Motions of these vast heavenly Globes, as they were so many round little Balls, floating and circulating in a Vessel of Water, which happens when the Water is put into a circular Motion; and they are not a little confirmed in such Fancies, by the Figures with which Astronomers are used to represent the Structure of the World, as may be seen in *Tab. XXII. Fig. 1, and 2.* where we find the Revolutions of the Planets represented like the forementioned Balls in Water, upon one and the same Plane; insomuch that there does not seem to be wanting any other Direction for their Motions, than only conceiving a circular Motion of the Matter in which they swim, and the rather, because if one moves the Water in a round Vessel swiftly about with a Stick, we may often observe some of the little Particles thereof whirling about their own Axes, and at the same time carried about the common Center; from whence they infer, that the Moons also of *Saturn* and *Jupiter* may be likewise carried about their respective Planets, as here at F and H, without any particular Direction.

And thus these deplorable Disputers are used to contemplate, and to account for the Wonders produced in the Heavens, without considering them otherwise than as very different Figures and Resemblances; and to make their Opinions pass with greater Appearance of Truth, they use those shallow Maxims of some Philosophers, That the most simple Hypothesis or Notions that People form of things, are always the truest; which being easily agreed to by the Ignorant, and those who endeavour to evade the Labour of a just Inquiry, satisfies them the better, and procures them the more Disciples.

But in case things happen'd after such a manner, yet from the Motion of this Matter that runs round, (if there be any such Matter) an over-ruling Power of the great Director may be clearly enough demonstrated; since Experience teaches (as shall be more fully proved by and by) that all simple Motions are perform'd in Right Lines, and that Bodies can by no means describe Circular ones without some particular Direction.

SECT. LXIX. *Those Evasions answer'd; First, By the Orbs in which the Planets move.*

BUT now when we turn away from this fictitious Heaven, which has no other Foundation but in the Fancy of those who only make use of it, that they may more conveniently (or according to them, more simply) form an

Hypo-

Hypothesis for the Appearances that are most obvious to them; and if we further apply our Contemplations, without any Prejudices, to those Things which the true Inquirers have discover'd by their Observations, about the Motions of the Planets, it may be concluded, and not obscurely, by every one, that the former Evasions are groundless: For, *First*, all these great Globes are far from being moved in one and the same Plane, as they are represented in *Tab. XXII. Fig. 1.* and tho' this be the usual Figure by which Astronomers represent the System of the World; we are to suppose the Planes of the Orbit of the several Planets to cut thro' each other, like two Hoops placed obliquely in each other. For Instance, let the Plane of the Paper upon which is drawn the third Figure in *Tab. XXII.* be the Plane in which the Sun revolves about the Earth (or the Earth about the Sun, for we do not dispute that Matter here) and let the Oval Figure *E A F B*, be in this same Plane; then let us farther suppose the second Oval *A C B D* to be so placed, that the Part *A C B* be above, and the other Part *A D B* under the Plane of the first Oval; so that these two Planes, like the two abovesaid Hoops, have nothing common to each other, but one only Right Line *A S B*. If then we take this last *A C B D*, for the Way of any Planet, we shall perceive how it differs from the Plane of the *Ecliptick*, that is, from the Sun's or Earth's Way, and makes an Obliquity with the same, so that there remains, between both the Planes, a Width, or Breadth, on the one Side, as *C F*, and on the other of *D E*.

SECT. LXIX. *The Properties thereof.*

Now to form a fuller and truer Notion of the Planets Orbits, we must lay down some Conclusions which are known and agreed to by all Astronomers, namely, That,

First, The Way or Orbit of each Planet is in a particular Plane, and peculiar to itself, so that at one Time it is at *C* above, and another Time at *D*, under the Plane *A E F B* of the *Ecliptick*.

Secondly, That even the Moons of *Saturn* and *Jupiter* don't move in the same Plane in the which either the Orbit of their Planet, or the *Ecliptick* lies, but that they decline from both, and according to the most accurate Observation, compleat their Course in a particular Plane. See *Whiston's Praelect. Astron.* p. 201. where he reckons up their Appearances.

Thirdly, That each of these particular Planes, in which the Planets move, do never intersect the Plane of the Sun's Way in the same, but all in different Lines: So that, for Instance, if *Mars* does it in the Line *A B*, *Jupiter* will do it in the Line *R T*, &c. See *Whiston's Praelect. Astron.* p. 191.

Fourthly, That even the Obliquities or Angles which the Planes of the Planets Orbits make with the *Ecliptick*, do not agree in any two, so as to be the same, but are different in all of them: They who desire to know the Occasion and Measure of these several Intersections and Obliquities of the Planes (called by the Astronomers the *Inclinations, Latitudes of Planets*, and *Lines of Nodes*) such as *A B*, *T R*, and *C F*, *E D*, may meet with 'em in the *Automaton* of Mr. *Huygens*, p. 447. and elsewhere.

Fifthly,

Fifthly and Lastly, We are to know, that all these intersecting Lines A B, T R, &c. tho' they all of 'em differ, yet each of 'em pass through the Sun S; so that that Luminary shines upon the Intersections of all the Planes of the Planets Ways.

SECT. LXXI. *Convictions from thence.*

IT is needless now to observe how much this differs from Globes or Balls floating in Water on the same Plane or Superficies. And I leave the most obstinate Atheist himself to judge, whether it be by meer Chance, or ignorant Laws of Nature, and without any directive Power, that such vast Globes (some of which are likewise attended with their particular *Satellites*) should each of them move about the Sun in a different Plane; and that every one should have continued his Course for so many Thousand Years, without ever failing, and unvariably preserv'd the same Obliquity, tho' the Swiftneſs of their Motion is such as far to surpass that of a Cannon-Bullet.

And in order to be convinced of the contrary, let an Atheist fancy to himself a Machine, representing to his View in little, the Motions of so many Globes about another Globe, each of them in an oblique Course one to the other, and every one of them moving with the same Velocity as a Man can throw a Stone, and at the same Time let him not know how these Globes are moved or projected. Now, if he discovered, or was told that every one of these Globes had continued in such a Motion but a few Years, without any Confusion, and did continue so daily, would he not think such a Machine to be the Workmanship of the greatest Artist in the World? How dares he then say otherwise of such an unconceivably glorious Machine as this stary Heaven!

SECT. LXXII. *The Atheists Evasions Answer'd, secondly, by the Planets continual Approach to the Sun.*

Now if what has been already said, concerning the wise and wonderful Direction of the Planets Motion, be not sufficient to convince the most obdurate Atheist; a gracious GOD has vouchsafed yet farther to represent and manifest to the Sight of every one, something in the Course of these heavenly Bodies, that seems to put beyond all dispute the Greatness of that Power which rules and directs them, and to reduce the Matter to an entire Degree of Certainty: In order to prove this, we affirm, and no body can deny it, that it is experimentally true, that all Bodies when put into a Motion, do go on in a Right Line, unless some other Cause or Power obliges them to recede from it; and it is known that a Stone A moved circularly in a Sling about a Point S (*Tab. XXII. Fig. 4.*) in the Circle A H D E, with such a Swiftneſs, that it cannot be brought down by the Force of its Gravity when it is at A, will not continue to move in the same Circle towards H, as soon as the said Sling is loose, and the Stone left to itself, but pursue its Way according to the Right Line A F, which touches the Circle at A; and this happens not only in a Circle, but in all other Curve Lines, as Experience teacheth us.

Now let the best Philosopher tell us, how it comes to pass, that such great Bodies as these Planets are, moving about the Sun with a Swiftneſs ſo much greater than that of a Cannon-Bullet, and with ſo prodigious a Force as has been ſhewn above, do not likewise obey this Law, and run always in a ſtrait Line, but deſcribe inceſſantly a Curve Line, and always return to the Point from whence they began; and how theſe moved Bodies are compelled every Minute to depart from their Right Line, and deſcribe by their Courſe the Orbit which they do.

For that the Planet A (*Tab. XXII. Fig. 5.*) being moved about the Sun in the Curve Line A E D Z, when it is at A endeavours to go to F, along the Tangent A P, and when at G tends to I, along another Tangent G Q, is diſputed by no body. Tell us then the Reaſon why ſuch a great and ſwift Globe, certainly tending from A to F, and from G to I, is continually pro-ruded or attracted to the Sun, or at leaſt is brought nearer to it; ſo that A F and G I, being the Lengths which the ſaid Planet is to run at each Place in the following Minute, in the Tangent Lines A P and G Q, it is forced to forſake them, and, in the very ſame Inſtant, to approach ſo much nearer to the Sun, as the Lines F G and I H are in Length; without which it would not be poſſible that this Planet could continue in its Curve Way A E D C about the Sun?

This is not to be answer'd by the Hypotheſis which ſome Philoſophers have hitherto maintain’d, That the Sun has a Vortex of a ſubtile Matter about it, which running round, drags the Bodies of theſe Planets along its Stream; forasmuch as the Gravity thereof remains the ſame; therefore they are bound to ſhew why that Matter itſelf deſcribes a Curve Line, and does not, like other Things, move directly, according to Tangents; ſo that here likewise we muſt have recourſe to a Power that governs the Motion of this Matter: But the famous Mathematician, Sir *Iſaac Newton* and others, have ſhewn, that we ſeek in vain the Properties of this Circular Motion in the Matter of the Vortices.

SECT. LXXIII. Thirdly, *By the Courſe of the Planets in an Ellipſis.*

BUT to cut off all Cavilling about this Difference, it may be ſufficiently proved from the Property of the Curve Line, according to which each of theſe Planets are moved, that there muſt be an inceſſantly directing Power that regulates their Courſes, and that they cannot alone be carried forwards by any circularly moving Matter.

For the continual Experience of all Aſtronomers, that have ſucceeded the Great *Kepler*, and Obſervations ſo frequently repeated, have put it ſufficiently out of all doubt, that the Planets are not moved in exact Circular Figures; in which Caſe it might be ſuppoſed, with ſome Appearance of Truth, that there is ſuch a whirling Matter; but they are Curve Lines of quite another Property than Circles, and appear by manifold Obſervations to be *Ellipſes*, or oval Figures, as you ſee in *Tab. XXII. Fig. 5.* A E D Z.

In theſe *Ellipſes*, as is well known to the Mathematicians, there are two Points K and S, each of which they call a *Focus*, or *Point of Burning*, from whence

whence the same may be described by a String K E S, fasten'd at K and S, and by a Nail at E, which being directed by the String, describes the Circumference E D Z A, as is known to Carpenters, Joiners, and other Mechanics.

In one of these *Foci* is plac'd the Sun S, about which the Planet is continually moving; A is the remotest, and D the nearest Point of the Orbit in respect of the Sun; for which Reason likewise, A the farthest, and D the nearest Point to the Sun, are termed by Astronomers, the *Aphelium* and *Perihelium*.

SECT. LXXIV. Fourthly, *Because their remotest Points extend to different Parts of the Heavens.*

AND that no body may imagine neither, that any ignorant Laws of Nature have any Place here in a Stream of *Vortices*, or whirling Matter, the adorable Creator, who alone will be acknowledged and glorified herein, has shewn, with irrefragable Proofs, his absolute Empire over these great Bodies, and likewise his wonderful Power in those vast and remote Spaces; for which Purpose he has not thought fit that the *Elliptical* Orbits of the Planets, as A E D Z, and L R, M T, (which very much differ in Magnitude and Distance from the Sun) should have their *Aphelia* A and L extended from the Sun S towards one and the same Place of the Heavens, as B; which would have appeared more convenient to our Conceptions, and might have been used as a Principle to discover, after this manner, a general Law of Nature, whereby we could have accounted for these Motions and Dispositions in the Heavens.

But on the contrary, to the End that every one who contemplates these great Works, might be certain that it is only the irresistible Will of a supream Director of all things that has place in this Matter, He has so order'd the Orbits of the Planets A and Y, namely A E D Z and Y V N W, for so many Ages, that the one seems to be entirely independant of the other; placing not only each of them in a different Plane obliquely upon the other, as we have shewn above, but likewise causing all the Lines proceeding from the Sun S, thro' the *Aphelia* or remotest Points A and Y, to tend to different Parts of the Heavens, as B and C, altho' the said Sun S, with respect to which only he has made them, does sufficiently appear in common to one Focus all these *Ellipses*: The Truth of this may be seen in all the Books of the Astronomers, and particularly the Places of the *Aphelia* of each in the *Automaton* of Mr. *Huygens*, p. 441.

SECT. LXXV. *Convictions from thence.*

NOW after having well conceived all this, those who think it concerns them to learn GOD from his wonderful Works, will be pleased to use their Endeavours, first, by what has been said, to gain a true Notion of the Planetary Heavens familiar to them, and comparing one thing with another, to consider whether a Man argues without Foundation, who maintains that the Power and Wisdom of the Great Creator shines out more brightly here than

the Skill and Contrivance of the Workman in the most curious Clock, or any other Machine whatsoever.

For, *First*, considering the almost unconceivable Magnitude of these wandering Globes, and their Distances from the Sun, which may only and easily be determined by the Diameters of the Earth. And, *Secondly*, seeing that *Saturn*, tho' it be distant from the Sun at least 100,000 of the said Diameters, according to the latest Observations, between every two following Points of its Orbit, is always attracted towards the Sun, notwithstanding there is not the least Band or Connexion between the one Body and the other. *Thirdly*, Finding that these Approaches to the Sun have place in all the Planets, tho' there is likewise no Union between any of them. *Fourthly*, Knowing that each of 'em performs its Course in a particular Plane. *Fifthly*, That they describe no Circles which we see generated in natural Motions, after different manners, but to shew that a particular Direction obtains here, they move in *Ellipses*, or oval Figures, every where preserving their Geometrical Properties. *Sixthly*, That these oval Figures are each of 'em extended lengthwise to a different Place in the starry Heavens. *Seventhly*, That their Motions have continued for many Ages in this Order, without any Confusion among each other. And, *Finally*, since no body who understands it right, can, without Amazement, observe that these Globes of such an amazing Magnitude (that *Jupiter* is at least 8000 times bigger than the Earth; and the rest, excepting *Mercury* and *Mars*, which are somewhat smaller) are either as big or bigger than the Earth itself, and yet all of 'em move about the Sun with so prodigious a Swiftmess, as far exceeds that of a Cannon-Bullet.

SECT. LXXVI. *The Motion of the Planets about the Sun.*

Now if we reflect upon the Experiments which, besides the foregoing, have been made by the modern Astronomers, and would be too tedious to be related here, new Wonders will occur to us at every Turn, and always administer fresh Occasion of acknowledging a tremendous Power, and a Direction continually exerting itself.

To say nothing therefore of the Comets and their Courses from and to so many different Places of this immensurable Space, since neither their Causes, nor the Ends for which they have been made, do yet fully appear to us: Let us once again bring before our Imagination those great Celestial Globes, the Planets, and consider, that in that incomprehensible Motion with which they circulate about the Sun in their Orbits, they likewise revolve or turn upon their own Axes from West to East, at least it has been visibly observed already in *Jupiter*, *Mars*, and *Venus*, and even in the Sun itself.

Thus we find (to say nothing of the Earth, since all Astronomers do not agree therein) that that dreadful Globe of Fire, the Sun, turns round upon its own Axis in 25 Days; *Venus* in 23; *Mars* in 24 $\frac{1}{2}$; and the great Globe of *Jupiter* in 10 Hours. See *Gregory's Astron.* p. 36. As for the rest, we have not yet been able to discover any thing certain about them.

And in order to convince every one of the Dreadfulness of the Powers which exert themselves in this Matter, we need only investigate the Swiftmess

fronting p. 446.

Fig. 1

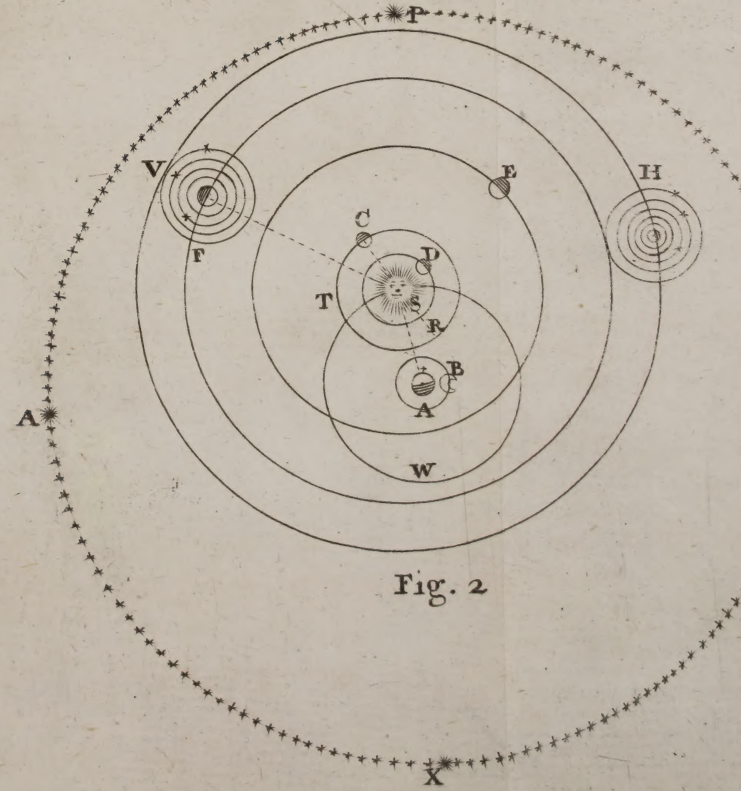
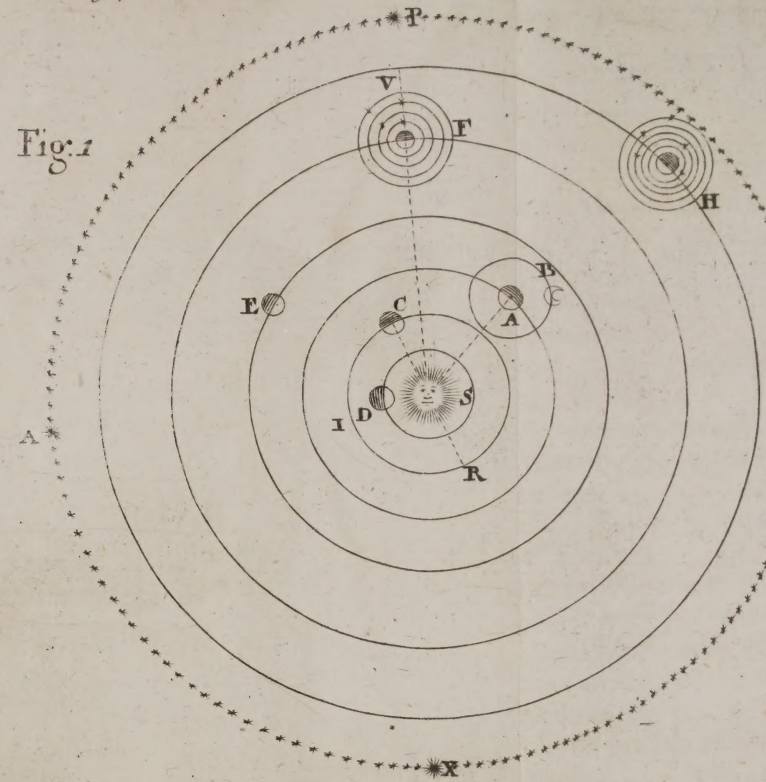


Fig. 2

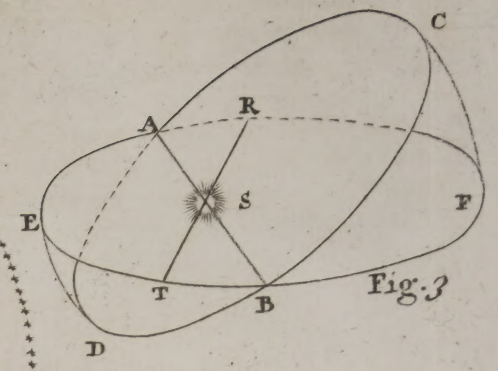


Fig. 3

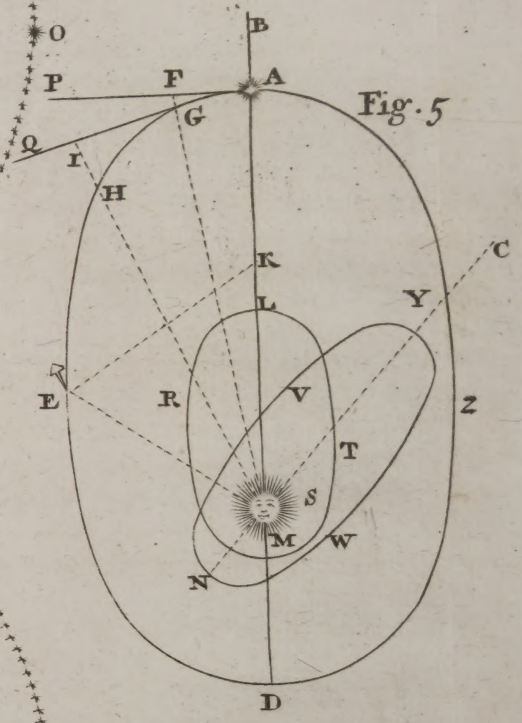


Fig. 5

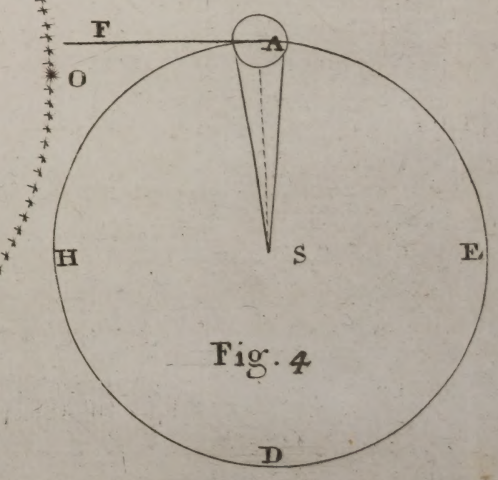


Fig. 4

nests wherewith these great Globes are carried about their respective Axes after the following simple manner.

For supposing the Earth's Diameter to be 6,538,594 *French Toises* or Fathoms long, the Circumference thereof will contain 23,541,600 of the same, since the Diameter of a Circle : Is to its Circumference : : As 7 : To 22, or yet nearer, As 113 : To 355.

Now each Point that is upon the Surface of the Earth at the Equator would run so many Fathoms in 24 Hours, and consequently $237\frac{1}{2}$ in one Second of an Hour.

But a Cannon-Bullet (as has been shewn above) runs 100 of the like Fathoms in a Second.

Consequently every Point upon the Equator of the Earth revolves with much more than twice the Swiftness of a Cannon-Bullet.

If then, according to this Proportion, the Velocity in the Revolutions of the other Planets be measured, and if it be supposed (to speak within compass) that the Diameter, and for the same Reason the Circumference of the Sun, is but 100 times bigger than that of the Earth, we shall find, that since it employs 25 Days in one Revolution about its own Axis, it turns four times as swift as the Earth, and each Point in its Equator consequently is moved 8 or 9 times as fast as a Cannon-Bullet.

So likewise *Jupiter*, which is 20 times as big as the Earth, and revolves in the Space of 10 Hours, would carry every Point in its Equator 20 times as fast about its Axis as those of the Earth; supposing that this Planet should likewise require 24 Hours for that Purpose; but as it performs the same in 10 Hours, its Velocity will be yet $2\frac{2}{3}$ times greater, or *Jupiter* will revolve 48 times swifter than the Earth, and each of the aforesaid Points move above 100 times faster than a Cannon-Bullet.

SECT. LXXVII. *The Velocity of Saturn, and of his Ring.*

LET us moreover cast our Eyes upon *Tab. XXIII. Fig. 2.* or the Representation of *Saturn* A, and its Ring GI, and consider, that this Globe H is about 2000 times bigger than the Earth, and that the Ring GI is full 4 times as broad as the Globe of the Earth is thick, and that the Space likewise between the said Ring and the Body of that Planet, is not less in its Breadth. Again, that this Ring is thin and flat, and no way adheres to *Saturn*, but is quite loose round about, as has been hinted above; yet that this Ring never forsakes nor stays behind *Saturn* in its Motion, but always accompanies it with equal Velocity, and has done so for many thousand Years, notwithstanding that that Globe moves about 20 times as fast as a Cannon-Bullet, as may be easily computed after the abovemention'd manner.





CONTEMPLATION XXV.

Of the Unspeakable Number, and Unconceivable Smallness of the Particles of which the Universe consists.

SECT. I. *Transition to the Smallness of Parts.*

IF now, after having Contemplated the visible World in some of its Parts, we turn our Thoughts farther, to those so wonderfully small and numerous Particles of which it consists; and then consider the Laws which they continually obey, tho' ignorant of the whole, and even of themselves too; and which Laws the Great Creator has been pleased to render subservient to the Execution of his marvellous Purposes; that Man must be quite blind and inexcusable, who cannot discover therein, the Power, Wisdom and Goodness of an adorable Ruler of the Universe.

The Reader must not expect to meet here with an exact Description of the Figures thereof, forasmuch as without ever being thoroughly fathomed or comprehended, they will always furnish new Matter of Inquiry to learned Men, as long as this Universe shall be preserved in its present State and Condition. We shall therefore only consider some Matters and Bodies with respect to their Smallness, not perhaps so thoroughly as the accurate Truth of the Thing may require, but only so far as Experience may lead us therein.

SECT. II. *All Bodies consist of small Parts.*

Now that all visible Bodies do consist of an unconceivable Number of such little Parts, is already admitted by all Philosophers, and demonstrated too by so many Experiments and Proofs, that no Body who has taken the least Trouble of examining the Nature of Creatures, can entertain any kind of Doubt thereof. Concerning which, *Rohault's Physics*, *Boyle's Subtil. Effluvia*, *Keill's Introduction*, and other Books may be consulted.

SECT. III. *Our Conceptions must be Rectified.*

BUT as our Imagination is incapable to represent to us the amazing Magnitudes of the Heavenly Bodies, so likewise we find it as little able to give us just Ideas of the Smallness of the Parts whereof all visible Things are composed; for which Reason as the former, so likewise the latter is by many thought incredible, especially by some of those, who, when they conceive Things according to Truth, are afraid they shall discover in them a great and terrible GOD.

SECT. IV. *A Cubical Inch contains a Million of visible Particles.*

ALL kind of visible Bodies may be divided into *Fluid* and *Solid*; we will begin with the First:

And before-hand advance what Mr. Boyle in the beginning of the second Chapter *de Subtil. Efflu.* affirms to appear by Experience; namely, that the Length of an Half-Inch can be divided into 100 Parts, which shall all of 'em be big enough to distinguish themselves for Use; but we, to prevent all Cavilling, will only maintain the same of an entire Rynland-Inch; from whence it follows, that a Cubical Inch, or a square Stone, which is an Inch long on all Sides, contains a Million of such little Cubes, each of which in all their Dimensions, or in their Length, Breadth and Thickness, are no more than the $\frac{1}{100}$ of an Inch long, which is known to every one that is a little versed in the Principles of Geometry.

So that we may safely lay it down for a Truth, (since if the Length of such a small Cube is visible, the whole little Cube will be much more visible) *That a Cubical Inch contains a Million of visible Parts.*

SECT. V. *A Cubical Inch of Water contains the like Number of Parts.*

Now if the Point of a Needle can be ground so sharp, that the Bigness of it may be equal to the Bigness of such a small visible Particle; and that this Point were to be just dipt in Water, and being drawn out again, should appear wet, or that some Water cleave to it, all which may be allowed without any Difficulty: If then it should be farther supposed, that there was but one only Particle of Water that stuck to it, and (for the more convenient Computation) that it was as thick as the little Superficies of the Point of the said Needle; and moreover, of a Cubical Figure, it is plain from the Premises, that it is no bigger than $\frac{1}{1,000,000}$ Part of a Cubical Inch of Water, and consequently that such an Inch contains a Million of Water-Particles, which if they were separated, would each of 'em be so big as to be visible. From whence it follows, that such a vast Quantity of Cubical Inches of Water as are in the Universe, in Air, Earth and Water, and are moved, must certainly contain so many Millions of Parts, and be as certainly moved.

SECT. VI. *A Cubical Inch of Water rarified in an Æolipile, will yield above 13300 Millions of Parts.*

BUT to proceed a little farther; Mr. Boyle, in the Third Book of the above-mentioned Treatise, says that (See *Tab. XXIII. Fig. 3.*) an Ounce of Water EFG, being put into a Copper Globe A, in which there was a little Hole at B; the said Globe, commonly called by the Learned an *Æolipile*, was put upon the Fire; whereupon the Vapours of the Water begun to be protruded thro' the said little Hole B, which produced a Pyramid of Vapours DBC, for the Space of 18 or 20 Minutes; the Length of which BR, was twenty Inches, and the greatest Breadth at CD, was of one Inch: Yet so, that at the Distance BM, (being five or six Inches farther than

than BR) they could perceive vapoury Clouds still hanging together, which extended themselves to the Breadth of four or five Inches at K L.

If now, for the more easy Reckoning, we consider the long Pyramid B D C, joined to the short one D C K L, as one only Pyramid; the Length of which from B to R, is of 21 Inches, and the Diameter from C to D of 1 $\frac{1}{2}$ Inch, the Superficies of the Circle C N D G will be $\frac{22}{7}$ Superficial Inches, which multiplied by 7, (being the $\frac{1}{3}$ of BR or 21) will amount to the Magnitude of $\frac{22}{3}$, or 12 $\frac{2}{3}$ Cubical Inches for the whole Vapour-Pyramid.

If this had been computed nicely according to Mr. Boyle's Measure, the long Vapour-Pyramid B C D, together with the short Cloud-Pyramid C D L K, would amount to above 32 Cubical Inches, tho' we should reckon BR to be but 18, C D, 1, R M, 5, and K L, 4 Inches; but for the greater Conviction, and to prevent all Cavilling, we have reckoned it all to be but 13 Inches.

Let us now suppose that one of the Particles of the Vapours rushing out of the aforesaid *Æolipile*, runs the Length from B to R in the Second of a Minute; so that in every Second there is a new Vapour-Pyramid formed: There would then in 18 Minutes, or in 180 Seconds, be produced so many different Pyramids.

Now each Vapour-Pyramid makes 12 $\frac{2}{3}$ Cubical Inches, and consequently all the Pyramids that are formed from one Ounce of Water, will produce 12 $\frac{2}{3}$ times 180, or 13,365 of the like Inches. If now in each visible Particle of all these Pyramids there is but one Particle of Water (since there are a Million of 'em in one Inch) there will be in the whole 13,365,000,000, and consequently one Ounce of Water may be really divided into 13,365 Millions of Parts at least.

But since it is desired to know farther, into how many Parts an Inch of Water may be likewise divided after the said manner; let us suppose that a Cubic Foot of Water weighs 64 Pounds, and that there are 10 Inches to a Foot; accordingly a solid Foot will contain 1000 of such Inches, and at the rate of 16 Ounces to a Pound, there will be 1024 Ounces in 64 Pounds. From whence it is easie to prove, that a Weight of one Ounce makes $\frac{1000}{1024}$ or $\frac{250}{256}$ of (or rather almost so many Parts of) an Inch; so that we may safely enough affirm, that a Cubical Inch of Water is according to this way divisible into 13,000 Millions of Parts.

SECT. VII. *There may hang above 13,000 Particles of Water to the sharp point of a Needle.*

NOW it appears from Section the 5th, that the Water which may stick to the extream Point of a Needle, which is so sharp, as to be just visible, and the Breadth of which is $\frac{1}{1000}$ part of an Inch, may safely be allowed to amount to the thousand thousands part of an Inch.

Therefore it is sufficiently certain, that this little Water that sticks to such a fine Point, does consist of no less than 13,000 Particles, if it be only a little Cube of Water that has the same Breadth.

SECT. VIII. *That a Drop of Water is divisible into above 26.000,000 Parts.*

BUT now let us compute with Amazement, how many Parts are to be found in one Drop of Water, upon the Supposition which has been just now proved, that as oft as one dips the Point of a Needle or fine Pin, and something adheres thereto, so often there are 13,000 Particles of Water requisite to compose the said Drop.

Now to form a rough Conception of this Matter from another Method ; let a Drop of Water be supposed to be of the Weight of a Grain, of which 480 go to an Ounce Troy-Weight, and compute according to the Rule of Three, that if 480 Grains gives $\frac{250}{480}$ Parts of an Inch, what gives one Grain ; and we shall find it to be full $\frac{1}{480}$ Part of an Inch.

Now to lose nothing, and to allow enough, let us make the Calculation with a smaller part of an Inch, namely, with the $\frac{1}{500}$ thereof ; and suppose that a single Drop, tho' it be greater, does not contain more Water-Particles than the said $\frac{1}{500}$ Part.

Now a cubical Inch of Water contains 13,000 Millions, or a Million of times 13,000 Particles, consequently $\frac{1}{500}$ of an Inch, or one Drop, contains 2000 times 13,000 Water-Particles, or in one Sum 26.000,000, that is, six and twenty Millions thereof ; of which if we again cast away six Millions, because we don't desire to have too much granted to us, it seems plain beyond Contradiction, that in one Drop of Water no bigger than $\frac{1}{500}$ of an Inch, there are at least not fewer than twenty Millions of Water-Particles.

SECT. IX. *Convictions from the foregoing Observations.*

BEFORE we proceed any farther, let an Atheist stop a little here, and consider with us, how great and how penetrating that Providence and Direction must be, which before a Drop of Rain-Water of the Quantity and Weight only of one Grain shall fall down upon the Earth, has thought fit to compound it of so many Millions of Parts.

And if he should refuse, as he has hitherto done, to own a Providence herein, let him tell us, whether he can persuade himself, that such an innumerable Multitude of Millions of Water-Particles could by meer Chance, or without any Wisdom and Direction for so many thousands of Years continually and incessantly proceed from Seas, Rivers, and other moist Places, rise up into the Air, divide themselves into Clouds, as it were into so many Armies ; where floating in that thin Matter, they are carried by the Winds towards so many different Parts, in order to compose whole Streams and Rivers ; to descend in Rains upon the dry Ground ; to cause the Fruits of the Earth to grow ; to furnish Drink to all kinds of Animals ; in a Word, to perform all those Functions and Services which we have before ascribed to Water, and to preserve the whole Globe of the Earth with almost all that is upon it, or proceeds out of it, alive and in good Condition. Certainly if this Atheist be any ways reasonable, he must stand amazed, *First*, at that Power which has made so many Thousand Millions of Water-Particles, as are to be found in Brooks, Rivers and Seas, and preserved them

in their Motion, Figure, and Quantity. *Secondly*, He can never sufficiently praise that most adorable Wisdom that has separated and, as we may say, rent all these Particles, and set each of 'em, how little soever they be, loose and free from the rest; without which Division they could not have ascended by reason of their Weight, nor hardly been of any Use. And, *Lastly*, that he is bound to return Thanks to this so gracious Benefactor, who has made such an unspeakable Number of Beings subservient to his, and all other Men's Advantages, after so multifarious a manner.

SECT. X, XI, and XII. *This Hypothesis founded upon the Observations of Mr. Leeuwenhoek, namely, That a Drop of Water contains many more than one Million Millions of Parts; the same applicable to all kinds of Liquids.*

I HAVE been willing to prove here by degrees, that the Particles of Water are exceeding small, to the end, that I might not at first deter our Imagination from contemplating the same, by reason of such a Smallness of which it can scarce possibly frame any *Idea* to itself; and therefore the Reader will be pleased to judge from what follows, whether he must not agree, that altho' the now computed Smallness does seem already to escape our Imagination, yet that it is far different from that which we must necessarily allow to be found in the Particles of Water.

Now to shew this, we will lay down for a Foundation, the Experiments of Mr. *Leeuwenhoek*, as they are described by him in his Letter of the 12th of Nov. 1680, p. 29; where he relates, that he distinguished in Pepper-Water, in the Sperm of Animals, &c. three sorts of *Animalcula* of different Sizes, of which if we take the Diameter of the smallest for the Measure of the others, and call it an Unit, that of the Second or next biggest *Animalculum* or Insect will be 10, and that of the Third or biggest 100 times as long as the Diameter of the Second; so that the Diameter of this last, is $1 \times 10 \times 100$, or 1000 times as long as that of the First.

If now for the more convenient Calculation, this last *Animalculum* and a Grain of Sand be supposed to be of the same Figure, for Instance, that each of 'em be either globular or cubical, the Grain of Sand will be so much bigger than the Body of this *Animalculum* as the Cube 1,000,000,000 of the Diameter 1000 of the last is bigger than the Cube 1 of the Diameter 1 of the first, and consequently we see that such a Grain of Sand is equal to 1000 Millions of these *Animalcula*, each of which are visible thro' a Microscope.

Now Mr. *Leeuwenhoek* (in his Discoveries the 26th of April, 1679, p. 14.) supposes that 100 Grains of Sand are equal to an Inch in Length; so that 1,000,000 of such Grains compose a cubical Inch.

If then we argue after this manner:

Since 1,000,000,000 *Animalcula* go to one Grain of Sand, and 1,000,000 Grains of Sand to an Inch (which we here reckon at $\frac{1}{12}$, and not $\frac{1}{16}$ part of a Foot) there will be contained in such a Cubical Inch 1,000,000,000,000,000 of those *Animalcula*.

But

fronting p. 452.

Fig. 2

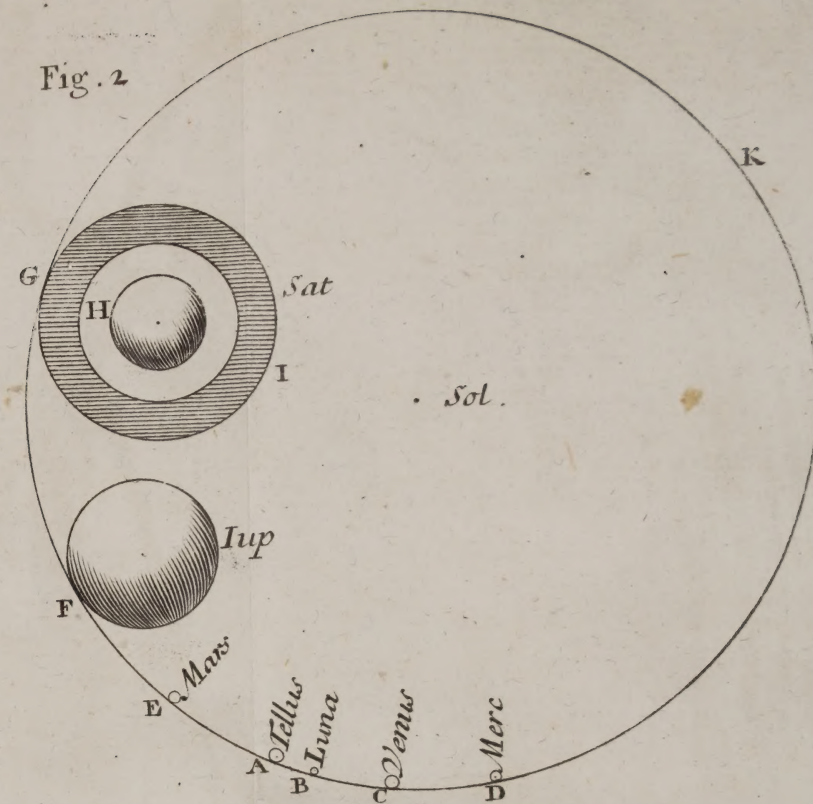
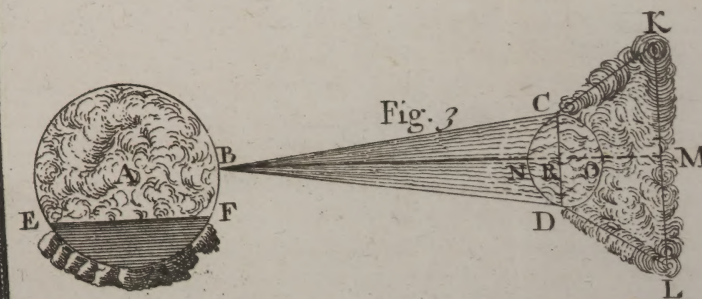
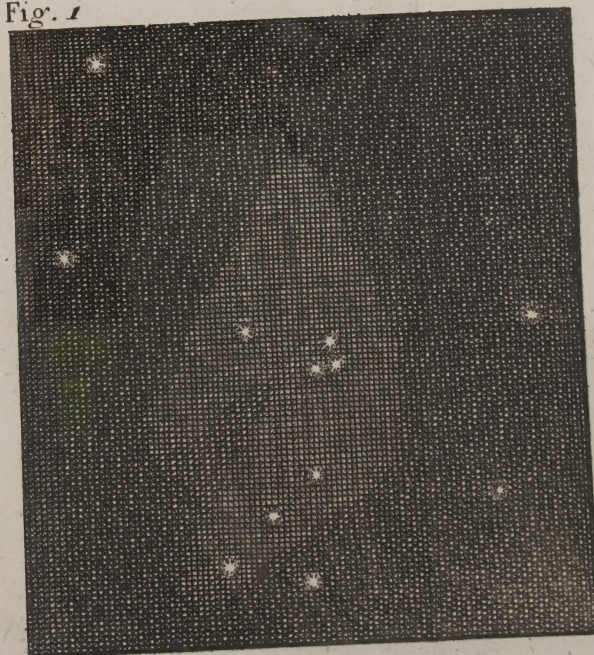


Fig. 1



But according to *Señ. VIII.* it appears, that one Drop of Water is $\frac{1}{1000}$ of an Inch; so then according to that Calculation, 2.000,000.000,000 *Animalcula* are but equal to such a Drop of Water.

But to prevent any Objections against the said Calculation, we will abate the half of it, according to which there will be then a thousand times a thousand Millions of these *Animalcula* capable of being contained in one Drop of Water.

Let us stop here again, and reflect with Amazement at that dread Wisdom and Power, which before He causes one large Drop of Water to fall from the Air, makes use every time of such a prodigious number of watry Particles for that Purpose.

This last being now proved about Water, we may easily see that it is applicable to many other fluid Matters, especially to such as are wet, and which by sticking to solid Bodies, do moisten the same; for which reason we need not say any thing of Oil, Spirits and the like; but we will add a few Words about other Fluids that are not moist.

SECT. XIII, XIV, and XV. *The Smallness of the Particles of Air, Fire and Light.*

THE abovemention'd Mr. *Leeuwenhoek* in his 7th Continuation, p. 424, says, that having pressed the Air and Blood out of the little piece of the Lungs of a Sheep, he found that many of the Air-bubbles were so small, that they were hardly visible, even with a Microscope; insomuch that they must be smaller therefore than those *Animalcula* which we have lately spoken of from him, and which could be seen; and consequently a Grain of Sand is more than equal to 1,000 Millions of the same, or a Cubical Inch will contain above 1,000.000.000.000,000 Particles of Air.

Now tho' some think they have reason to believe that the Particles of Air are bigger than those of Water, because the latter can pass thro' Orifices or Holes, which seem impervious to Air; yet we see that the Particles of this latter are exceeding small, since it might be demonstrated here, that by reason of their Invisibilty, they far surpass in Smallness the abovemention'd *Animalcula*.

Certainly that they do likewise penetrate thro' very narrow Passages, is not only plain from Plants, into all which they insinuate themselves, tho' we cannot discover any Pores or Cavities in some of 'em; but it is likewise well known to those that use Air-Pumps, who find how much Pains it costs them before they can exhaust the Air; at least if it may be proved, as perhaps it can, that the Particles of Water are smaller than those of Air; this is still sufficient to convince us particularly, that we are far from having as yet investigated the real Smallness of the Particles of Water.

Now how much more minute Parts Fire consists of than all these abovemention'd Fluids, may appear from hence, that Air, Water, Oil, and the like, are found to consist of such gross Parts, that they cannot pass thro' the Pores of Glass and other hard Bodies, as Iron, Steel, &c. and can therefore be excluded or kept out from Vessels made of those Materials; whereas

there are no Passages, tho' ever so small, in any Bodies thro' which the Particles of Fire cannot penetrate; which appears by their rendring all Bodies either glowing, that is to say, full of Fire-Particles, or putting them into Fusion, or causing them to evaporate; of all which nothing could come to pass, if the Fire were not able to insinuate itself into the innermost Parts of those Bodies.

We should now pass on from the Fire in the last Place, to its Effluvia or Matter of Light, and give the Reader here a rough Sketch of the Fineness of the Parts thereof, since we are far from being able to trace the Multitude and Smallness of them, and particularly have given a certain Demonstration how many Particles of Light may be safely affirmed to fly out of a burning Candle in the Second of a Minute.

They that have not a mind to read the following Demonstration, may pass on to *Sett. XVI, and XVII.*

A Calculation of the Number and Smallness of the Particles of Light.

I. It is supposed that the Flame of a Candle of Six to the Pound, may be seen at the Distance of 2000 Paces, or 10,000 Foot, each Pace being computed at 5 Foot; that is, from O to E. *Tab. XXIV. Fig. 1.*

II. It is plain then, since the said Flame may be seen at the same Distance all round, that it fills the whole Globe or Circle R Q E S.

III. Now to find the Bigness of this Globe R E, we must first observe that the whole Diameter is equal to twice O E, that is 20,000 Foot.

And so far as much as 100 : 1 is to 314 : : As the Diameter R E : To the Circumference R Q E S, we shall find, by the *Rule of Three*, that this Circumference includes 62,800 Feet.

IV. Now if we multiply the whole Diameter by the Circumference, and that Product by the sixth Part of the Diameter, it will produce the solid Contents of the Globe R Q E S, being 41,866,000,000,000 Cubical Feet, as is known to all Geometricians.

V. If now we divide a Foot into ten Parts, and call each of 'em an Inch, 1 Cubical Foot will contain 1000 Cubical Inches; as the aforementioned Globe will contain 41,866,000,000,000,000 Cubical Inches, which for Shortness, and that we be not every time obliged to write the said Sum at length, we will express by placing the Number of the Cyphers omitted over the first Cypher: So that according thereto, such a Globe contains 41,8660²² of such Inches.

VI. Again, since a Candle of 6 to the Pound will burn five Hours, it may be easily computed how much thereof will be spent in a Second; for allowing 3600 Seconds to one Hour, and to every Ounce (16 of which make a Pound) 480 Grains, Apothecaries Weight, we shall find by the said *Rule of Three*, there is burnt in one Second $\frac{16}{225}$, that is, full $\frac{1}{14}$ Part of a Grain of Tallow.

VII. Now to know how many of these Grains of Tallow, or Wax, go to one Foot:

Let us suppose, *First*, that a Cubical Foot of Water weighs 64 Pounds, to which the Weight of most Waters will amount.

And, *Secondly*, that 5 Feet of Water are as heavy as $5\frac{1}{2}$ Cubical Feet of Wax. Vid. *De Stair, Senguerdius, &c.*

Supposing then Wax and Tallow to be of equal Weight, since the Experiment of burning 5 Hours has been made with a Tallow-Candle, 5 Feet of Water will amount to 320 Pounds Weight, and so will $5\frac{1}{2}$ or $5\frac{6}{8}$ Feet of Wax or Tallow.

So then a Cubical Foot of Wax weighs 60 Pounds, that is 460,800 Grains, and consequently 1 Grain the $\frac{1}{460800}$ Part of a Cubical Foot of 1000 Inches, which being reduced to single Inches, amounts to $\frac{1}{4608}$ or $\frac{1}{460}$ of a Cubical Inch.

VIII. Now if we consider here likewise the aforementioned Velocity of Light, and suppose O E the Distance of the Candle O to the End of the enlighten'd Globe Q E R S, to be 10,000 Feet; and whereas it has been already proved, that the Light of *Jupiter's* Moons passes thro' the whole Space which is between the Sun and Earth, or 12,000 Diameters of the Earth, in the $\frac{1}{2}$ Part of an Hour, or 450 Seconds, that is, in one Second $26\frac{1}{2}$ of the said Diameters; it will follow then, that every one of these Diameters being computed at 39.231,564 *Paris* Feet. (See *Whiston, Praelect. Astron.* p. 13.) according to the most accurate Measure of the *French*, the said Light will run 1,046.175,040 of the said Feet; since so many of 'em go to the said $26\frac{1}{2}$ Diameters of the Earth.

But in Case any one should affirm that this Calculation is too large, forasmuch as it supposes that the Light of a Candle runs as swift as that of the Sun, he must be pleased to observe, *First*, That it has not been yet demonstrated, that one kind of Light moves faster than another: For if a Man were placed in a great dark Room, and a Hole were made in the same, for the Day-Light to pass thro', or before which Hole a Candle were held, I don't think that the Light of the Sun would reach him sooner than that of a Candle, at the same Distance. But it is hardly possible to make such an Experiment, because the Difference between such great Velocities of both these Lights is not to be observed. *Secondly*, Because Light does probably not vary its Swiftness at all; since the surprising Emanation of Light, of which mention has been made before, and is now here repeated, is not observ'd with respect to those Rays that proceed immediately from the Sun, but only as they be reflected from *Jupiter's* Moons. So that it retains still this Velocity after having run above five times the Length of that Space between the Sun and Earth; for so have we shewn above, in *Contemplation XXIV.* that *Jupiter* is at such a Distance from the Sun. *Thirdly*, Besides several other ways by which we might prove the unconceivable Velocity of the Particles that proceed from a burning Candle, the same does appear by the Effects it has in melting Glafs, Enamels, Metals, and other very hard Bodies; which Force, since it can't be ascribed to the Magnitude of the Particles, they being exceeding small, must needs result from their Velocity; it being a known Rule in Mechanicks, that

that all the Force of Bodies is in Proportion to their Mass multiply'd by their Velocity.

But that we may here likewise concede enough, let us suppose, that instead of so many more than 100,000 times, in which the Light would fill this Globe in one Second, it be only 1000 times, whereby the Motion of the said Light is granted to be above 100 times slower, as it must be, if we compare its Velocity with that of the Light which comes down to us from *Jupiter's* Moons.

IX. We suppose farther, that the smallest *Animalcula* that can be render'd visible by the best Microscope, is much bigger than any Particle of Light. *First*, Because many more Particles of Light than one are requisite to render it visible. *Secondly*, Because these *Animalcula* are visible, whereas the Particles of Light are invisible. *Thirdly*, Because Light can pass thro' the imperceptible Pores of Glass, which the smallest Insect in the World can't do. And, *Fourthly*, this appears very plainly to such as know that these *Animalcula* being view'd against the Sun with a good Microscope, it is observ'd not only that they are transparent, but also that the Rays which pass thro' them, represent all the Colours of the Rainbow; to produce which, many and different Rays are necessary. The *Phænomenon* is familiar to those that deal in Microscopes, and we find it confirm'd in the *seventh Continuation* of *Leeuwenhoek*, p. 100. We premise this, for the sake of what follows, namely, That an inexpressible Number, or 10^{12} (a Unit with 20 Cyphers) of Light-Particles is really contain'd within the Space of one of these so small Insects; as also to assist the Weakness of our Imagination.

X. It is likewise known, that when a burning Candle placed at O, (*Tab. XXIV. Fig. 1*) and diffusing its Light as far as E, and filling the whole Globe E Q R S, communicates the same to the Point A, which is near the Candle, the said Point A will be as much more enlighten'd than another Point E, which is at an equal or greater Distance from thence, as the Square of the greatest Distance (for instance, of OE) is greater than the Square of the Small one O A.

In the Language of the Mathematicians, what we have laid down above, is express'd in the following Manner:

The Number of the Particles of Light in two equally great, but unequally distant Places from the Flame, are to each other in an inverted Ratio of the Squares of their Distances. This has been shewn more circumstantially above in *Contemplation XXIV.* and is well known to all Mathematicians.

XI To proceed a little farther :

Suppose then that OE, or the utmost Extent of the Light in the illuminated Circle QRSE, be of the Length of 10,000.000,000 or 10^{12} of such *Animalcula* as Mr. *Leeuwenhoek* view'd with his Microscope [why we restrain it to just this Number, shall be shown hereafter in *Num. XXIII.*] and let the Length of the Ray OE be divided into the smallest Parts OA, AB, BC, CD; allowing to each of them the Length of one of the said *Animalcula*.

If now it be farther supposed, that in the Space of that *Animalculum*, which is the last and most remote from the Candle O, as here at VE, there be

be but one single Particle of Light; and that the nearer these Points come to the Candle in every following Space, as DO , CB , BA and AO , the Light-Particles always and continually increase in the *Animalcula*, according to the aforesaid Rule, *Num. X*. It may be accordingly known, how many Particles of Light are contain'd in the Space of an *Animalculum*, the Distance of which from the Candle O , is likewise known, as here at OA , AB , BC , &c.

XII. For this Purpose, and for the sake of Order and Conveniency, let there be perpendicular Lines of an indefinite Length drawn upon the Points A , B , C , D , and all the Partitions of these Lengths of the *Animalcula*, such as Ag , Bb , Cc , Dd , Eg , &c. in order to describe thereby the Number of Light-Particles which are to be found in the Space of each particular *Animalculum*.

And having taken at Eg the Length EF , equal to an Unit, forasmuch as in the last Space VE , there is suppos'd to be contain'd but one single Particle of Light; and OE being found as above, to be equal to 10^{20} , say, according to the foregoing Rule:

1. As the Square of OA , or 1 : Is to the Square OE , or 10^{20} : So is FE (a Light-Particle in VE): To Aa , 10^{20} , or the Number of Light-Particles in OA .

Take then in the indefinite Line Ag , the Length Aa equal to 10^{20} , so will this Line Aa represent the Number of the Particles of Light at A , or in the *Animalculum's* Space OA .

2. As 4 , or the Square of OB , which contains two *Animalcula*: Is to the Square of OE , or 10^{20} , which contains the Length of 10^{20} *Animalcula*: So is 1 or FE : To $10^{\frac{20}{4}}$ or 250^{18} Bb .

3. So likewise when OD contains 10 *Animalcula* in Length, to find Dd , or the Light-Particles that are in D .

As 100 , the Square of OD , $10 =$: To 10^{20} , the Square of OE : So is 1 , or FE : To $10^{\frac{20}{100}}$ or 10^{10} , or Dd , and so of all the rest.

XIII. From hence then it appears, that if Perpendicular Lines, such as Aa , Bb , Cc , Dd , &c. be let fall upon all the Partitions A , B , C , D , &c. as the Line OE is divided into 10^{20} Parts, and each of them amount to the Number of the Light-Particles contain'd in the Spaces of the *Animalcula* OA , BC , AB , DD , &c. there would be nothing requisite more than to add up the Numbers of all the said Perpendicular Lines together, in order to know how many Particles of Light are contain'd in all the *Animalcula* Spaces of OE , as they increase after the said manner from E to A , in which there is no Difficulty.

XIV. As likewise by drawing GF parallel to OE , so that AG , Br , Cs , Dt , &c. be each of 'em equal to FE , or an Unit; that the Sum of all those Units will produce the Number of all the Light-Particles that are contain'd in OE ; if in each *Animalcula's* Space, OA , AB , BC , CD , &c. there be found but one Light-Particle.

Now since OE is supposed to consist of 10^{20} *Animalcula* Spaces, the Number of Light-Particles in the same will likewise be 10^{20} .

XV. From whence it therefore follows, that the Number of Light-Particles in the Length OE, supposing there be one in each *Animalcula* Space: Is to the Number of the same, supposing likewise, that they increase according to the Rule *Num. X.*: : As 10^{20} , or so many Units as are contain'd in the Lines A G, B r, C s, D t, &c.: Are to the Produce of all the Numbers that compose the Perpendicular Lines A a, B b, C c, D d, &c.

XVI. It is not necessary to prove that the Numbers of all these Perpendiculars A a, B b, C c, D d, &c. do contain so great a Quantity:

Since the first and greatest A a being 10^{20} ,

The Second B b will amount to $10^{\frac{20}{4}}$, or 250,

The Third C c $10^{\frac{20}{9}}$,

The Fourth D d $10^{\frac{20}{16}}$,

And so forth; each of these Lines equal to the Line A a or 10^{20} divided by the Squares of their Distances from O; all which amounting to the Number of 10^{10} ; so as the last F E, by an Unit, will produce a great Sum, which to compute here would be a very great Trouble, and require too much Time and Room.

XVII. That we may not therefore be deceiv'd in our Calculation, we shall make choice of a much smaller Sum than we need do, and therefore only retain the Number 10^{20} , that alone being the greatest Quantity of Light-Particles in the Space of one of the *Animalcula*, or the Line A a; and we will throw away the rest B b, C c, D d, &c. which would likewise amount to a vast Sum.

And having done so, it will easily follow, that the increased Light-Particles 10^{20} , or A a (*Num. XVI.*): Are to the Number of Light-Particles in OE: : As 1 in the Space of each *Animalculum*, or to 10^{10} (*Num. XIV.*): As 10^{20} to 1. Or that (if we admit the Increase, *Num. X.*) the *Animalcula* in OE are 10^{20} times more than if we were to suppose but one in each of the Spaces between O and E, Q R S E. This is applicable to all the Rays like OE thro' the enlighten'd Globe, and consequently to the said whole Globe.

XVIII. Before I proceed, I beg leave to obviate the Opinions that some People may entertain of these Matters:

Namely, That since the Curve-Line a, b, c, &c. F which connects all the Tops, a, b, c, &c. of the Perpendicular Lines A a, B b, C c, &c. which are here drawn so close to each other, is of a known Property; which, if we call each of the Lines or Distances O A, O B, O C, &c. x, and the respective Perpendiculars A a, B b, C c, &c. each y, and the Line OE, a, and EF, b, and expresses the same by the following Algebraic Equation, $xxy = ab$. A Mathematician will wonder, perhaps, why I did not find the Area of the Magnitude of the *Mixtilineum* A a F E by Approximation, or even after the Method of *Mercator*, *Wallis*, and other great Mathematicians; to the end, that after having compared the same with the Greatness of the Rectangle A G F E, to find the Proportion from thence of the increas'd Number of Particles of Light in OE to the Number of the same OE, if there were but one Particle in the Space of each *Animalculum*; which has been done, it may be, by others on the like Occasion.

But they must be pleas'd to observe; *First*, That I have omitted these Methods, because all of 'em suppose, that the Line O E is to be divided into infinite small Parts, as O A, A B, B C, &c. whereas we have only adapted our Divisions to such Parts are equal to the Space fill'd by each of those *Animalcula* that are visible thro' a Microscope, which is yet bigger an infinite Number of times than one of the infinite Parts.

Secondly, We have given one Reason in *Num. XVII.* which will make our Conclusions much more acceptable, because we chuse so much smaller a Number.

Thirdly, What we here write is not so much for great Mathematicians, as for others that are of a good natural Understanding, tho' not thoroughly vers'd in Lines and Figures; wherefore, when we can use other Methods of Proving, we avoid as much as possible those of the Mathematicians; my chief End being to render my self intelligible even to the meanest Capacity, rather than to please the Learned, provided I can make the Truth appear in such a manner.

XIX. To draw therefore those Conclusions which we have in View from these and the foregoing Principles; let us suppose, (1.) with *Leeuwenhoek*, that 1,000,000,000 of those *Animalcula* which are visible thro' a Microscope, do make up one Grain of Sand, *Sett. X.* (2.) That 1,000,000 of Sands are equal to a Cubical Inch, *Sett. X.* according to which 10^{22} of these *Animalcula* are equal to a Cubical Inch, allowing but 10 Inches to a Foot in Length.

Now according to *Num. V.* the Globe Q R S E contains 418660^{12} of such Inches, and consequently 418660^{26} of the said *Animalcula*.

XX. Let us suppose further, that in every one of the Spaces fill'd by each *Animalculum*, there is but one Light-Particle thro' the whole Globe.

XXI. If now the Velocity of Light be so great as to enlighten this Globe in one Second, (See *Num. VI.* and *VIII.*) and a Candle of Six to the Pound will burn 5 Hours, there will be $\frac{1}{5}$ part of a Grain of Tallow spent in each Second. Consequently there will proceed from $\frac{1}{5}$ of a Grain of Tallow 418660^{26} Particles of Light, and 14 times so many, or 5161240^{26} from a whole Grain.

XXII. But one Grain is $\frac{1}{460}$ Part of an Inch of 10 to the Foot, *Num. VII.* there proceeds therefore from one Inch of Candle-Tallow 460 times 5361240^{22} ; or in one Number 269617040^{22} Particles of Light.

XXIII. But supposing with Mr. *Leeuwenhoek*, 1000 Diameters or Lengths of one of these *Animalcula* equal to one Grain of Sand; and 100 Diameters of one Sand, to be the Length of an Inch, and 10 Inches the Length of one Foot.

Then 10^6 Diameters of the *Animalcula* make the Length of one Foot, and 10^{12} of the same, the Length of O E, or 10,000 Feet.

XXIV. Now we have shown, *Num. XVII.* that altho' we throw away many Thousands of Millions of Light-Particles in the Globe Q R S E, there be really 10^{12} more Light-Particles, than when as above in *Num. XX.* we suppose but one single Particle in the space of each *Animalcula*. So that

there proceeds from $\frac{1}{4}$ of a Grain of Tallow, 10^{10} times more Particles than are supposed *Num. XXI*; and consequently from one Inch of Tallow, 10^{10} more than in *Num. XXII*; that is, from one Inch of Tallow there will proceed 269617040^{22} such Particles.

XXV. And all this is true: *First*, Altho' we should suppose that there is but one Light-Particle in the Space of one *Animalculum*, at the extreme Part of the illuminated Globe, or at V E, which every Body sees is too little, considering the gradual Increase of Light, as we come nearer to the Candle O. And *Secondly*, although the said Globe should be enlighten'd but once in one Second, or that the Light passes from O to E in that time.

But so far as according to *Numb. VIII.* the Light runs 1000 times swifter, and does not only run once, but 1000 times the Length of O E on all Sides, there being 1000 of such Globes fill'd with Light by $\frac{1}{4}$ Part of a Grain of Tallow in one Second.

It plainly follows, that the Number found by *Num. XXIV.* must be multiply'd by 1000; and that one Inch of the Tallow in such a Candle does emit 269617040^{40} Particles of Light, whereby the most astonishing Smallness and Number thereof is plainly *Demonstrated*.

SECT. XVI. *How many Particles of Light fly out of a burning Candle in a Second.*

To know then how many Particles of Light fly from a burning Candle in the Second of a Minute; it has been demonstrated from the foregoing Considerations, that $\frac{1}{4}$ of a Grain of Tallow is consumed in the Second of a Minute, or, which is the same thing, one whole Grain in 14 Seconds. Now an Inch of Tallow contains 460 Grains, so that an Inch of Wax, or Candle-Tallow, is burnt in 460 times 14, that is, in 6440 Seconds; in which time if there proceeds 269617040^{40} Particles of Light from an Inch of Tallow, there will fly out of a burning Candle in the Second of a Minute, the Number of 418660^{32} Particles.

SECT. XVII. *The Particles of Light compared with the Sand of the whole Earth.*

AND since according to the most exact Measure of the *French Astronomers*, the Diameter of the Earth amounts to 39.231,564 *Paris Feet*, reckoning 10 Inches to one Foot, and that 100 Sands are equal to one Inch; the Number to be taken for all the Sands that could be contained in the Earth, will require a Sum of not less than 32 Figures, the first of which is a (3,) and the whole too long to be expressed here.

Now in *SECT. XVI.* the number there found was 44 Figures, of which the first was a (4.)

Now let us for Conveniency, and to prevent any Disputes, suppose, that both the first Figures were a (1,) and the rest Cyphers or Noughts, by which we lose an unconceivable Number of Parts: Accordingly the Sands of the whole Earth will be 10^{32} .

And the Particles of Light flying out of a Candle in a Second 10^{43} .

The

The Proportion of the one to the other, will be As 1 To 10^{22} , or As one To a Thousand times a thousand Millions.

From whence it may be concluded, that in one Second (which is commonly equal to one Pulse of an healthy Man) there fly out of a burning Candle of Six to the Pound, many more Particles of Light than a thousand times a thousand Millions of that Sand the Number the Earth can contain, or be equal to.

I leave every one to consider, whether this does not appear most amazing to him, and whether he is not bewilder'd, and looses himself in the Number and Smallness of these Particles of Light, tho' there were no more of 'em; whereas every one may perceive from what has been said, that if we had kept to a strict Calculation, the Number thereof would very far, yea unconceivably, surpass what we have here set down.

SECT. XVIII. *The Smallness of Parts in solid Bodies, such as Copper, or Brass, &c.*

LET us now pass on to solid Bodies (tho' the Division of this Tallow may likewise be serviceable to the same Purpose) and endeavour to shew, First, That they consist of a vast Number of different Particles. Some of the most intelligible Methods seem among others to be the following.

1. Mr. Boyle (*de Subtil. Effluv.*) says, that a Grain of Copper having been dissolved by him in Spirit of *Sal Armoniac*, did thereby communicate a visible blue Colour to 28,434 Grains of Water.

Now if we suppose that each Grain of Water was impregnated with one Particle of Copper, it will follow from thence, that one Grain of Copper was divided at least into so many Parts as there were Grains of Water.

But supposing with Mr. Boyle, that $\frac{1}{100}$ of an Inch in Length is visible, $\frac{1}{100,000}$ of a Cubical Inch will be likewise visible.

And since one Foot of Water of 64 Pounds (allowing 12 Inches to the Length of one Foot) contains 1728 Cubical Inches; the aforesaid 28,534 Grains will amount to above 100 of the said Inches; and consequently in all those Inches there will be more than 100,000,000, or one hundred Millions of visible Parts; wherefore if there be but one Particle of Copper in every visible Particle of Water, a Grain of Copper will be thereby really divided into so many Parts.

SECT. XIX. *The Smallness of Parts in solid and fluid Matters in general.*

Now how far the Parts of Gold may be really extended by human Instruments, has been shewn by Rohault, Boyle, and others.

One Proof which is as applicable to all solid Bodies as well as fluid, may be briefly shewn in the already-mention'd Experiments of the Microscopes of Mr. Leewwenhoek; by which it appears, that of those smallest *Animalcula* which he could see thro' them 10^{15} , or 1,000,000,000,000,000 go to the making up of one Cubical Inch. Now it is certain, that if the Particles of which a Body is composed are so small, that each of 'em are invisible to the Microscope, every Inch at least of the said Body must consist of more than 10^{15} of such Particles.

From whence then the same may be truly affirmed of all Metals, Minerals, Animals, and Plants, in a word, of every thing that is visible.

And no Body ought to be surpriz'd, if we should add, that this Number of Parts is much too small to express properly the Multitude thereof; and this may certainly be proved in many Cases, if it be consider'd;

First, That these small *Animalcula*, which are only visible thro' the Microscope, must be furnished likewise with the proper Instruments for Life, Motion, and Procreation, as also with their Juices by which they are nourished; to the Smallness of which, no Power of human Imagination seems capable of being extended.

Secondly, That almost all Animals and Plants are combustible, and may be put into a perfect Flame; for which Reason, if we only make a rough Estimate (according to what has been said above, *SECT. XVI* and *XVII*, of the Smallness of the Particles of Light) how much greater the Flame proceeding from them is, than that of a Candle; and consequently, how many more Parts do every Moment fly out of them under the Figure of Light, all which did contribute before to the Structure of such a Plant or Animal, such a Multitude, and such a Smallness of Parts, will result from thence, as (to those who do not see the Force of these Consequences) must seem incredible, and unconceivable even to those that can see them.

SECT. XX. *Experiments shewing the determinate Properties of these small Parts.*

NOW that these numerous Particles which flow from Bodies, are not only very small, but have likewise a determinate Nature and Essence, has been shewn by the Learned Mr. Boyle in a particular Treatise, to which we refer the Reader.

But to say something of the Matter; *Glass of Antimony*, as is well known to those that understand the Virtue of it, being infused in Wine, will make a Vomit, tho' the *Antimony* loses nothing sensibly of its Weight; and the Parts of it are so exceeding small and fine, that an Ounce or less would furnish Vomits for more People than are in the whole City of *Amsterdam*.

From whence appears, not only the Smallness of those Parts, which it communicates to the Wine, but also that the Nature thereof is determinate.

Gold, Silver, Mercury, it may be other Metals too, being dissolved in their respective *Mensstruums* are divided into an infinite Number of invisible Particles; and they may be all precipitated, as the Chymists phrase it, or caused to subside in those Liquors, and be returned again into their several Metals.

How small the *Effluvia* are that come out of a *Loadstone*, and which will even pass thro' Glass to move Iron, is plain enough from such an Effect; and withal, that they have their determinate Properties.

SECT. XXI. *Of the Smoak of Benjoin.*

THEY who desire to see a Calculation of the Smallness of the Particles that exhale from sweet or stinking Matters, such as Musk, Civet, Ambergrease,

grease, *Assa Fœtida*, and the like may meet 'em in Dr. Keil's *Introduction*, and yet they all retain their particular and determinate Scent: To say nothing of the Particles which a Hare or other hunted Beasts leave upon their Footsteps, since Mr. Boyle has expressly treated of the same, it may be proved from the following Experiment, without any Trouble or Charge, of how many Particles a solid Body consists.

In a Chamber that was 24 Foot long and broad, and about 16 Foot high, I placed little Pans of Fire in four several Places, and strewed upon each of 'em about $\frac{1}{4}$ of a Dram of *Benjoin*; whereupon, the Chamber, after some time, was full from one end to the other, of a thin visible Smoak.

Now the Contents of this Chamber were 9216 Cubical Feet, which being multiply'd by 1000, or the Number of Inches in a Foot (supposing it be divided into 10 Parts in Length) amounted to 9216,000 Inches.

Now $\frac{1}{1000}$ of an Inch in Length is visible to the naked Eye, (*Seet. IV.*) consequently then $\frac{1}{1000.000}$ of a Cubical Inch; so that there being 1.000,000 visible Particles in an Inch, there were 9.216,300.000,000 of the same in this Chamber; and in case there were but one Particle of *Benjoin* in each, the eighth part of an Ounce of the said Perfume, would be thereby divided into more than nine thousand thousand Millions of Particles, tho' the same be much smaller in quantity than an Inch.

If now we add here, not only that this Smoak diffused the Scent of the *Benjoin* in all the Parts of the Room, but likewise, as the Chymists know, that the said Smoak being collected, does yield a purified *Benjoin*, called the *Flower of Benjoin*; besides the Smallness of its Parts, the settled and determinate Property thereof may be proved from thence; and that as well these small exhaled Particles do retain the Nature of the *Benjoin* itself, as the Vapours do of the Water out of which they proceed, and into which, being collected, they are turned again.

SECT. XXII and XXIII. *Convictions from the Smallness of Parts in General, and in Particular.*

Now let an unhappy Atheist, who has not only understood all that has been here said of the Smallness and Multitude of these Particles, but who by Reading and Reflecting has made the Contemplation thereof habitual to him; let such a one I say, set before his Eyes the great Structure of the visible World, and all its Parts; and let him consider not only of what an innumerable, unexpressible, yea, and unconceivable Multitude of Atoms the same consists, but particularly, that none of 'em all have the least Knowledge or Skill to create or move themselves; and let him judge farther, that if no Wisdom had intervened in this Matter, and that all their Motions had been produced without any Order, and by meer Chance; whether it would not be certain, that this noble Frame of Heaven and Earth would have been quickly turned into a *Chaos*, in which Fire, Water, Air, and all things besides, would have been confusedly jumbled among each other; and so much the more, if there had not been a Power so unconceivably great as to extend itself to every Individual of all those thousand thousands of

unex-

unexpressibly many Millions of Millions, and which could have directed and governed each of 'em in Particular; which Direction is therefore necessary, because each of 'em have their determinate Properties; and therefore one kind of 'em is not adapted for executing such a Purpose as may be performed by the other.

Or if this Proof be too general for these miserable Philosophers, so that they will fancy to themselves, that perhaps they may find out here or there some Subterfuge among this great Number of Objects, let them cast their Eyes upon Particulars; let them read all the modern Discoveries by the help of Microscopes; let them apply themselves to see with their own Eyes what they had heard before thereof; and that travelling thro' this new World, which for so many Ages has been invisible, they may contemplate those numberless strange Things, which would have been incredible, if Experience had not render'd them certain: And when they have been assured by their own Sight, that, for Instance, such a little contemptible Creature as a Mite in Cheese appears to the naked Eye, is a compleat Animal, having all those Limbs and Joints that are proper for its Motion, and its Body cover'd with Hair: that such Insects couple with each other, lay Eggs, from which their young ones are hatch'd; that farther, on the contrary, the little Eels that may be discover'd in Vinegar, lay no Eggs, but bring forth their young ones alive. This last we are told by Mr. *Huygens* in his *Dioptrics*, p. 227; where he says, that he saw in such an Eel four young Eels for they are entirely transparent) and that after having kept the old Eel a little longer in the Glass Tube, the four young ones were observed swimming by their Dam.

And if this Contemplation alone may have so much Power over them, as to force them to confess, that an over-ruling Wisdom prevails in all these Matters; the Smallness and innumerable Multitude of these Objects in which its wonderful Operations appear, will easily convince them, that there must be something Divine therein; and it may serve at the same time to illustrate that great Article of Christianity, namely, *That even the most minute Things cannot by their Smallness escape the Direction and Providence of the great Creator.*

SECT. XXIV, and XXV. *The Hand of God particularly manifested in the Use of these small Parts.*

LET not then any Infidel who only reads the Bible to form Objections against it, imagine any longer that it was almost an incredible Hyperbole used by the Saviour of the World, when he was pleased to say, *Matth. x. 30.* That *the Hairs of our Heads are all number'd*: Since we have shewn a Providence, exerting itself with respect to those *Animalcula*, that can by no means be compared with one single Hair for Greatness; and since in one Second of a Minute there are more Particles of Light diffused from a burning Candle on every Side (all which, as the Mathematicians know, are most exactly governed and directed by the Laws of *Optics*) than there are Hairs upon the Heads of any one Man living, tho' that Person had as many Hairs upon his Head as there are People in all the World.

To set this Matter in a true Light, tho' it may be very easily deduced from the foregoing : It has been shewn in *Seet. XVII.* that the Number of Particles of Light that proceed from the Flame of a Candle in one Second, is much greater than a certain Number, the first Figure whereof is 4, followed by 43 Cyphers, or 40^{43} .

Now Mr. *Leeuwenhoek* in his *First Letter*, p. 14. finds, that the Number of Men upon the whole Earth, according to his Calculation, amounts to 13,385,000,000 or 133850^6 . Now let us compute this Number at above much more than 10 times the same, and suppose it to be 20^{11} .

Now if every Man had so many Hairs upon his Head as 20^{11} (which is much too many) the Number of the Hairs of all Men would be 40^{22} , which, as appears, would be no more than a 10^{22} part of the Particles of Light that proceed from a burning Candle; so that from hence we may conclude, with the utmost Certainty, that the Son of GOD, far from using an Hyperbolical Way of Speaking, falls much short of the ordinary Operation and Direction of his Providence, how figurative soever this Expression may appear to weak Men.

Besides all this, it may perhaps be an Inducement to an Atheist to acknowledge a GOD, if he considers, that this adorable Creator and Governour of all Things has thought fit to shew particularly thereby his Godhead and Sovereignty over all his Creatures; that in order to produce the greatest and most surprising Events and Things, he oftentimes makes use of no other but these small Particles, these contemptible Atoms, or Points, making infinite Numbers of the same subservient to his wise Ends and Purposes.

To prove this experimentally, the whole World may in a manner serve for an Example: for to say nothing of the Smallness of those Particles which cause Pestilences and contagious Distempers, whereby so many thousand Men are often snatched away in a little time (in which therefore King *David* acknowledged the Hand of GOD appearing after an eminent manner; *2 Sam. xxiv. 14.* and which even at this time are called by many *the Gift of God*;) how small and numerous are the Parts of Water, of which above a thousand times a thousand Millions are necessary to make up one Drop, or one single Hail-Stone equal to the Weight of one Grain? And to how great Purposes are they used, for which Water would be entirely unfit, if it were not capable of being separated and divided into Particles of an innumerable Multitude, and of an unconceivable Smallness? How many thousand Millions thereof ascend daily out of the Seas and other Streams? How many of 'em float in the Air; and that we may not repeat what we have said before in the *Contemplation of Water*, how many fall down in Rain, how many in Snow, how many in Hail, how many in Dews and Mists; how many are employed in the Nourishment and Increase of Plants, and in Drink for Animals; how many in barren Wildernesses, and for the Support of the wild Beasts therein? And must it not be confessed, that all this depends upon the Divisibility, and upon the actual Division of Matter into an infinite Number of small Particles.

SECT. XXVI. *Convictions from several Texts of Scripture.*

NOW he that can still deny a GOD, let him sit down, and seriously reflect on this great Truth; and then let him judge how vast that Power must be, who, to demonstrate beyond denial his infinite Existence to the Confusion of those that blaspheme his Holy Name, brings about such great Events, by such small Atoms: and who has not only created such an extended Quantity of Water as that is, which can contain all the Water of this Globe, but who has likewise separated and divided it into such small Particles; and how far that Wisdom and Direction can go, which extends itself to every one of these numberless little Parts, and makes them all continually subservient to such important Uses as these are. And if he says he can't discover a GOD in all this, let him show us the Creatures, or, to speak in his own Language, the Natural Causes, to which so much Power and Direction over these and a thousand other small Particles besides, may justly be ascribed. If he deduces all this from meer Chance, how then can he derive so steady an Order and Regularity, which has prevailed so many Ages among such numberless Millions, from Chance, whose very Essence consists in operating without Order? If he says, it is owing to unalterable and necessary Laws of Nature; who has then given Forms and Bodies to all these different Beings that know nothing of their own Existence? And who has bound them to obey certain Laws? If therefore a Wisdom is to be seen in all this, yet is it not to be found in a Matter that is ignorant of every thing: And where must a reasonable Man look for a Cause of all, and such a Cause as can quiet his own Mind, if he does not acknowledge a GOD therein?

In case now this Proof, which is only deduced from the Particles of Water, seems to be of any Weight to an Unbeliever, (who nevertheless acknowledges a GOD,) the Wisdom of the Divine Word, and the Truth which shines out of it, will not seem obscure to him, soasmuch as they demonstrate a GOD from the *Rains and Floods of Waters*, and that the true GOD is thereby distinguish'd from the Idols. See *Jer. xiv. 22. Are there any among the Vanities of the Gentiles that can cause Rain? Or can the Heavens give Showers? Art not thou he, O Lord our God? Therefore we will wait upon thee, for thou had made all these things.* We likewise see that his Saints deduce a particular Argument from thence to praise GOD. *Psal. cxlvij. 7, 8, 9. Sing unto the Lord a thanksgiving; sing praise upon the Harp unto our God: Who covereth the Heaven with Clouds, who preparerth Rain for the Earth, who maketh Grass to grow upon the Mountains. He giveth to the Beasts his Food, and to the young Ravens, which cry.* We likewise find the Almighty himself enumerating this among his Glorious Wonders, *Job xxxviii. 25, 26, &c. Who hath divided a Water-course for the overflowing of Waters? Or a way for the Lightning of Thunder, to cause it to Rain on the Earth, where no Man is; on the Wilderness wherein there is no Man? To satisfy the desolate and wast Ground, and to cause the bud of the tender Herb to spring forth? And he asks further, in the 28th verse, hath the Rain a Father? Or who hath begotten the drops of the Dew? By which he shows that the Rain has no Father or Mother; that is to say, no other Origin but from him.*

'Tis true, that the Greatness of GOD is mostly proved here by the Benefit which the Earth and the Inhabitants thereof do reap from Water itself; but that the same Spirit which dictated those Expressions, proves the same from the Smallness, and consequently the Number of the Watry Particles, may be inferr'd from the before-quoted Texts of *Job xxxvj. v. 26, 27 and 28*, in the XIXth Contemplation, where after having said, *Behold God is great, and we know him not, neither can the Number of his Years be searched out.* He presently after subjoins the Reason, in v. 27. *For he maketh small the Drops of Water; they pour down Rain according to the Vapour thereof.* And pressing further to show that Rain consists of the great Number of these Watry Atoms, he says in the 28th verse: *Which the Clouds do drop, and distil upon Man abundantly.* From which Text it therefore plainly appears, that not only the Smallness, but the Numbers of Watry Particles are meant.

As likewise in the Prophecy of *Nahum i. 3.* *The Lord hath his Way in the Whirlwind, and in the Storm, and the Clouds are the Dust of his Feet.* By which last Words is plainly shown, that the Clouds are compos'd of exceeding small and numerous Particles, compared therefore to *Dust*, and that the Holy Ghost does justly fetch a Proof of the Greatness of GOD from thence.

SECT. XXVII. *Convictions from the Smallness of the Particles of Air.*

Now tho' the innumerable Multitude of the Particles of Water only might seem sufficient to convince the most harden'd Atheist of the Direction of GOD in those great Events, which tend as well to the Advantage as Punishment of Mankind; yet if that can't satisfy him, let him consider the Air in the true State thereof: And if he has any Knowledge of Nature, he will admit it as an indisputable Truth, that the Substance of the Air is a Collection of innumerable Diversities of small Parts, which acting upon each other, do oftentimes exert such a Power as surpasses even all Belief. Let him only read concerning this Matter, the Histories that give us an account of the dreadful Force of Storms and Tempests, of Thunder and Lightning: Now 'tis plain, that all these terrible Effects are brought to pass by Particles, which are so small, and so light, as to be able to float in the Air; and that Lightning particularly finds no Pores of the very hardest Bodies so close and narrow, but what it can penetrate.

We have mention'd something of the Air above in *Sect. XIII.* but which falls far short of expressing upon those Principles the Smallness and Number of its Parts; and if in one Pulse or Second of a Minute there do proceed so many thousand Millions of Particles of Fire and Light from the small Flame of a Candle, how vast must the Number be of those that proceed from greater Lightnings, and how small each single Particle thereof?

Let then this unhappy Reasoner represent to himself the Air composed of such numberless Millions of Particles, and reflect upon the Force which they produce, when they operate in Storms and Tempests, so as to threaten the World with a universal Desolation; and then let him tell us whether he thinks it possible, that all these Aerial Armies are moved by *Chance*, and that they have not yet destroy'd all that is upon Earth; and consequently whether he

does not think it absolutely necessary to own a Divine Direction and Government over all these things, and by which he and all that belongs to him, have been hitherto preserved, and the whole Earth render'd habitable: It is impossible but any Man who has long and seriously meditated upon these Things, and the Number and Strength of the Particles of Air, and of the Power that is requisite to keep them all in order, and to do good to the World after so many ways, by the things which might otherwise be very destructive Instruments, it is impossible, I say, but he must consent to the Truth of what we have here advanced.

SECT. XXVIII. *Convictions from the Smallness of the Particles of Fire.*

AND for greater Conviction, let him farther add Fire or Light to Water and Air, and he will find not only that the Parts thereof are unconceivably Small and Numerous, but also that the Powers of it are most Terrible. Not to speak again of Lightning, which is an amazing Instance thereof, he who has ever read in History, how by the Violence and Number of these small Fire-Particles, Subterraneous Caverns have burst open, and caus'd Earth-quakes; whole Rivers have flow'd with burning Matters; Cities and every thing in them have been destroyed; Rocks and Mountains split asunder, and sometimes vast Pieces of them, which did not seem capable of being moved by any human Strength, tossed up into the Air to an incredible height; must he not acknowledge that all these stupendous Effects have been brought to pass by the most minute Particles of Fire, and such as could hardly be conceived for their Smallness? That he may satisfy himself thereof without much trouble, let him only look back to *SECT. XVI.* and consider what has been there said about it, namely, that from so small a Flame as that of a Candle, there proceeds in the Second of a Minute, a Number of 41,866 with 39 Cyphers following, of Particles of Fire and Light.

Let him now compare therewith the Flames of Lightning, of burning Mountains, of all the combustible Matters in the Earth, supposing them to be inflamed; that mighty Globe of Fire the Sun, and perhaps likewise thousands of fix'd Stars; and then let him reflect with Amazement, how great an Host of numberless Particles of Light and Fire are to be found in the World; for, that no Man living is able to compute the same, I believe he will readily agree.

Now since this dreadful quantity of Light and Fire-Particles does not set the World in a Flame (and that it is possible for them to do so, has been already exemplified in Burning-Glasses) it is plain enough that they must have been restrained by some superior Power from making such a Havock and Destruction.

And now if a Sceptick is desirous to see, and as it were to feel with his Hands a divine Direction of these Particles of Light and Fire, he needs not Contemplate all the combustible Bodies in which so many thousands of 'em lie dormant, and as it were lock'd up and fetter'd till the Time that they are to be put into Operation (which likewise proves the Direction of a Superior Power) but let him only consider the Optical Experiments, which
will

will convince him, that all and every Particle of this vast quantity of Light, are so strictly bound to certain Laws, that falling upon reflecting or transparent Bodies, they are compelled to adapt their Motions to the Diversity of their Figures, and even to unconceivable Circumstances; with Instances of which Sir *Isaac Newton's Optics* abound.

SECT. XXIX. *Convictions from all the foregoing.*

IF all this be not sufficient, let a Man who still doubts of these great Truths, represent to himself of what small Particles not only Water, Air, Light and Fire, but even without Distinction all other visible Bodies whatever are composed. To begin First briefly with Plants and Animals, which are subject to Combustion and Putrefaction; what small Vessels and Tubes through which yet smaller Particles of Saps and Juices do pass, are discover'd in the same by the help of Microscopes? (about which Mr. *Leeuwenhoek* and others may be consulted) How many Fat and Oleaginous Parts are to be found in the same? (of which likewise Candles are made from some Animals, an Inch of whose Fat is divisible into such an unconceivable Number of Parts by Inflammation, as we have shewn above, *Seet* XV. and XVI.) How small and numerous are the Particles which from Putrefaction fill such great Spaces of Air with Stench? How much Water proceeds from thence by Distillation? which in *Seet* XI. has been shewn to consist of so numerous and small Particles: And when all these, both Animals and Plants, have undergone the utmost Corruption, they are changed into a fruitful Earth and Matter: How many Particles, especially if viewed with a Microscope, might we find in the same Earth? Now if we cast our Eyes farther upon Metals and Minerals, those Glasses will likewise convince us of the smallness of their Parts; and yet more, if they be dissolv'd in *Aquafortis*, and most of all, if they burn or tinge the Flame with their Particles.

To conclude; after having read all this, and what more can be met with upon the same Subject from other Inquirers, I think we may safely affirm, that every thing that is visible in the World, is composed of an unconceivable Number of various Particles. Let an Atheist therefore represent to himself this innumerable Quantity of thousands of Millions, and consider, *First*, of how many different Kinds they consist, which are each of a particular Nature. *Secondly*, How many Kinds must be often made use of in the Composition of one only Body, as we find by the modern Observations of Chymists, and others, who extract from every Plant or Animal, Air, Fire, Water, Salt, Spirit, and Earth, in so great a Diversity; how many various Compositions they make; how from the same Seas and Rivers, Air, Clouds, Winds, Sun, Stars, Trees, Shrubs, Herbs, Flowers, Fruits, Bodies of Men, and other Animals, such as Birds, Fishes, Beasts, Earth, Sand, Stones, Metals, Salts, and a thousand other Things, that have each their Singularities and Properties, are produced. *Lastly*, How, only by the Disposition of the Particles and Atoms which are in themselves invisible, this great, this wonderful Universe is maintain'd in its State and Condition, and all living Things are preserved.

And let him then answer us with Sincerity, and without Prejudice and Obstinacy, and especially without stopping at the Fear of finding God therein, because he has blasphemed and deny'd him (*seeing there is Forgiveness with him, that he may be feared*) I say, let him answer us this Question: Supposing one should show him several fine Powders of beaten or grinded Colours, each one in its kind, mingled with Oil, and at the same time a noble Landskip of Men, Trees, Flowers, Rivers, Beasts, Birds, and such like, consisting only of these so differently mingled Colours; can he really fancy or persuade himself that the said Landskip existed without the Art of a skilful Painter, and that it was made by mere Chance; or will he pretend to say, that he knows any Laws in Nature, which operating without Knowledge, are capable of imparting such Perfection to the fine Piece? And as it is impossible for him to maintain such a Position, or to convince himself, or any other Man of the Truth thereof, will he still impiously deny that all those glorious Works, in Comparison of which the best Picture he ever beheld, is but botching and bungling, were produced by an infinitely wise Artificer? Since the Disposition of so many Parts, and of so many Properties as are necessary to the Production of the most despised little Herb, of a Mite in a Cheese, or any other yet smaller Insect (to all which no Knowledge can be ascrib'd) must convince him of the Wisdom of their Maker.

Now how invisible soever the aforesaid Smallness, especially of the Parts of solid Bodies is, and consequently unknown; yet we see the Supreme Wisdom plainly teaching us all the same Things in his Holy Word, *Prov. viii. 26. As yet he had made the Earth, nor the Fields, nor the highest parts of the Dust of the World.* Could the inspired Writer express in more clear Terms, that the whole World is compos'd of very small Particles, which he here calls *Dust*?

And, as if this were not sufficient, we see the same Spirit manifesting the same Thing by the Holy Apostle *Paul*, with no less Emphaticalness, in *Hebr. xi. 3. Through Faith we understand the World was framed by the Word of God; so that Things which are seen, were not made of Things that do appear: Insinuating not obscurely, that every Thing which is visible, consists of such very small Parts, as that it does thereby become invisible, agreeable to the late Discoveries and Experiments, whereof we have treated above.*

SECT. XXX. *Great Bodies are for the most part divided at first into small Particles, before God is pleased to make use of them.*

AND that we may see how often the wise Director divides great Bodies into such small Particles, before He thinks fit to make them become Instruments of his Power; let us consider of how little Use and Advantage Water, for Instance, would be whilst it remained Ice, or a great hard and solid Body, in Comparison of what it is when fluid, and divided into Millions of Particles: Whilst it remains Ice, can it so conveniently supply Drink to thirsty Animals, or Nourishment to Plants? Can it bear loaden Ships, and carry them through the whole World? Can it ascend into the Air, in order

to

to come down again in Rains and Dews, or render those innumerable Services which Men reap from it when divided into minute Parts?

Whilst Fire being collected and shut up in Turf, Wood, Coals, and other combustible Matters, composes great and solid Bodies, what Effects can it produce in such a State? And unless those great Bodies be first divided into small Particles, and Flame produced by the Motion thereof, can they be any ways useful for Warmth, for Light, for melting Metals, for preparing Food, and other necessary Purposes?

The most active Matter that we know of amongst humane Compositions, is Gunpowder: What can it do whilst it is only Salt-Petre, Brimstone, and Coals? But when those smallest Particles of which it consists, are let loose and put into Motion, what is there in all Nature here upon Earth, and round about us, that can resist its Violence? Insomuch, that even Thunder and Lightning, which are observed to be the most terrible Powers in the World, tho' they likewise are composed of such fine Particles as are capable of floating in the Air, are so exactly imitated thereby, that he who sees the Flame of the former, or hears the Noise, and sometimes feels the Earth trembling under his Feet, has oftentimes Reason to doubt whether it be not really natural Thunder and Lightning which produces those amazing Effects.

We may learn from hence, as from an Experiment made, and serving only for that Purpose, how great the Force of the Particles is, which, as far as our Inquiry can extend itself, must be esteemed the most minute of all, such as simple Fire and Light.

But to bring no other Instances, it seems plain enough from these, and the like, what we have undertaken to prove, namely, that the Almighty, in order to convince even the most obdurate Atheists, does ordinarily make of none of the great Bodies, in the Operation of his most remarkable Wonders, 'till he has divided the said great Bodies into such fine and minute Particles, as are almost unconceivable by the Mind of Man.



CONTEMPLATION XXVI.

Of Certain Laws of Nature.

SECT. I. *What a Law of Nature is.*

WE understand by this Expression, nothing more here than a kind of Property or Power producing something in or about Bodies or their Parts, and which may be experimentally proved in certain Circumstances to have always place in the same; but we shall not pretend to a deep Scrutiny

tiny here, whether they be produced immediately by the First Cause, or by Second or Intermediate Causes acting in or about them.

SECT. II. *The Laws and Powers of Cohesion.*

IF then we reflect on the inexpressible Number and unconceivable Smallness of the Particles of Matter of which the Universe consists, even the most obdurate Atheists cannot deny, that Laws are necessary in order to produce this beautiful World, and all that is to be found therein. And if every thing were moved by mere Chance, working without Rule or Order, (just as if little Particles of Dust were blown by different Winds) no body that is reasonable, but must confess, he could expect nothing but the utmost Confusion from thence.

The first Law or Power then that occurs to us, is that of *Cohesion*, whereby certain determinate Kinds of Atoms adhere to each other, in order to produce together certain determinate particular Effects.

Let then an unhappy Philosopher tell us, when he sees so many Men, Beasts, Plants, Heavenly Bodies, and whatever else can be reckon'd among Corporeal Beings, formed with so great Regularity and Order by such a *Cohesion* of Parts, whether there be not infinitely more Wisdom required thereto, than to build a House of the necessary Materials of Wood, Stone, Iron, Glass, &c. supposing them to be all prepared and brought together for that Purpose; and certainly he would not ascribe this latter to Chance, or the ignorant Laws of Nature only.

Now with how great a Force the Parts of some Bodies, such as Flints and other Stones, Diamonds, Iron, and other Metals do *cohere*, is manifest by Experience, and particularly from the Violence that is requisite in many, to separate the Parts from each other. But if any one should object, that this *Cohesion* is only produced by Rest of the Parts among one another, and that in order to continue Bodies in Rest, there is not so much Wisdom or Power necessary; he may learn from Mr. *Marriotte, de Percuss.* Part II. Sect. 2. and from Mr. *Huygens*, Sect. 3. that he is mistaken therein; those Gentlemen having proved, that a Body, how great soever, upon the least Percussion or striking of another, how little soever it be, loses its Rest, and is put into Motion; which yet is never experienced in hard Bodies, the Parts of which (were they as hard as possible) if they only cohered by Rest, might be blown away and scatter'd with the Breath of one's Mouth, like a Heap of Dust.

Besides the Greatness of this Force of *Cohesion*, it is likewise wonderful to observe the Variety thereof, by which every thing is and remains adapted to its proper Uses after a particular manner. Thus if all the Parts of the Tongue cohered, or were so strongly join'd together as those of the Teeth, it would be immoveable; and if the Teeth were as soft as the Tongue, they would not be fit to grind our Food: If the Parts of Corn and other Meats with which Men and Beasts are nourished, were as hard, and cohered as closely as Iron and Flints, the Earth would be soon dispeopled. If therefore any one be still so blind as not to discover in the Manner and Variety of Powers of this *Cohesion*, or of the Hardness and Softness of Bodies, an infinite Wisdom; why

does

does not he maintain likewise (to make use of a plain Comparison) that our Beds and Blankets are soft, and the Wooden Frames belonging to 'em are hard, by mere Chance, and without the Design of the Workman?

SECT. III. *The Laws and Powers of Separation.*

Now if all the Parts of Matter should be subject to no other Laws but only those of *Cohesion*, the World would be filled with all the Carcasses of Men and Beasts, with all the rotten and putrified Plants, as with an odious and loathsome Burthen; and every thing remaining without any Alteration in its Corporeal Figure, would be entirely useless to many Purposes. Now can an unhappy Sceptick observe herein no Wisdom of the great Governour of the Universe! Forasmuch as those very Parts, which in other Circumstances did before strictly cohere, are compelled to obey other Laws and Powers, and to separate themselves from each other. By this Means the World is disburthen'd and released from so many unnecessary things, the Parts of which are divided from each other by Fermentation and Putrefaction; and afterwards again several other Matters are formed thereof, as for Instance, the most fruitful Lands, and many other Advantages do result from thence, of which a Multitude of Examples might be given; but we shall mention no more here, having already spoken of this Circulation of Matter upon other Occasions.

SECT. IV. *The Unattrition of such fine and tender Particles.*

BUT there's still a Law and Power, which will amaze every one that reflects upon it, namely, that these Particles of Matter, so small and so fine, should have continued for so many Ages without *Attrition*, or wearing away; notwithstanding that they have undergone so many *Frictions* or Rubbings, so many *Percussions* or Strikings among themselves, or against other hard Bodies, besides Motions innumerable; insomuch that it should seem, that in so many hundreds of Years they would have been entirely ground to Atoms, or all their Angles and Corners, being worn away, become round; which Figure Experience teaches us to be the last that all Bodies assume, before they be perfectly bruised or ground away: Who can imagine, that it should be possible that the Particles of Fire, after such dreadful and raging Motions among each other; the Particles of Air, after violently striking by Thunder and Lightning, by Hurricanes and Storms, against other hard Bodies; the Particles of Water, after so many Frictions, for Ages, against sandy and stony Beds, and against Rocks, should still preserve the necessary Forms, were it not that this Law of Unattrition of the smallest Particles did obtain in Nature? or that others were continually produced in just the same Number, neither more nor less, in the stead of those that were consumed? Both which prove a Divine Providence.

SECT. V. *Two Principal Laws of Nature, Percussion and Attraction, &c.*

FROM these Powers we shall now pass on to others, of which there be two principal ones, and according to the Laws of which, most Bodies dispose themselves: The *First* is *Percussion*, the *Second* is, by very great Mathematicians

ans of this Age, termed *Attraction*; to which some likewise are wont to add consequentially, the *Power of Repulsion*.

Two Bodies are said to strike when one of 'em runs against the other which is at Rest, or likewise if the last meets the first: as also when the last running slower than the first, is overtaken, whether the Way along which the Motion happens be in a Right Line or Oblique with respect to each other.

We don't here dispute whether some Philosophers are in the right, in deducing almost all Causes of natural Appearances from these Percussions; but that there is an infinite Number of such Motions at all times in the World, is unquestionable. Let us only consider the unconceivable Number of Parts of which Fluids consist, and imagine that many thereof, as Air, Light, Fire, Water, &c. are in continual Motion, which could not happen without Millions of Percussions against one another in an Instant: Now if there were no Laws observed by them herein, let us think what a Confusion all Things would be in.

Now what these Laws are, as has been shewn by *Wallis*, *Wren*, and *Huygens*; and Sir *Christopher Wren* in particular has proved, that the same do experimentally agree with the Things themselves, which Mr. *Mariotte* has thought fit to describe in a distinct Treatise. Now let an Atheist consider whether it can be without a superior Direction, that so many thousand Millions of Bodies, all of 'em entirely ignorant of what they are doing, should have so strictly obey'd the Rules of Mathematicks for the Space of so many Ages.

And since among these Laws that are observed in the Percussion of Bodies, there are likewise found such which may indeed be deduced by Consequence from others that are intelligible, but of which notwithstanding the Manner how these Laws are performed, is incomprehensible to every one; let an Atheist think whether we ought not to conclude from the Incomprehensibility of the Manner of the Operation, the Incomprehensibility of the Operator himself, and thereby acknowledge a Wonder-working God.

To give an Instance thereof here: It is obvious to those that understand the Mathematicks (but who can comprehend the *How* thereof?) that a Body in the Percussion does communicate not only a greater Degree of Velocity, but also a greater Force and Motion to another, than it first had itself, and yet almost retain all its own. The great Philosopher for Motion, Mr. *Mariotte*, calls this, in his *Treatise of Percussion*, p. 153, 154. a very *surprising Paradox*; and a few Lines below, a *wonderful Thing*; and that he might leave it past doubt, proves it experimentally.

And Mr. *Huygens* demonstrates, in what he has writ upon this Matter, that if one placed a hundred Bodies next one another in Rest, of which each following was always half as big as the preceding; and in case the Motion begins from the biggest; the Velocity with which the smallest would proceed, would be 14,760,000,000 greater than the Velocity with which the biggest was moved; but in case the Motion begins from the
smallest

smallest, the Greatness of the Motion in the whole will be so much the more augmented, as 4,677.000,000 is more than an *Unit*.

Mr. *Whiston* has transferr'd this from Mr. *Huygens* into his *Praelect. Phys.* p. 55. and names the first, a wonderful Augmentation of Velocity; but the last, a more wonderful Augmentation of the Greatness of Motion.

To pass on now to a second Kind of Powers :

It is said, that the Body A (*Tab. XXIV. Fig. 2.*) has an *Attractive* or a *Repulsive Force* (*Vim Attracticem vel Repellentem*) or otherwise, that the Body B gravitates to, or is repell'd from the Body A, when we see that another Body B is moved towards, or driven from A, without the Intervention of any other Bodies, which by protruding the said B, may be affirmed to produce such Motion.

A Philosopher who ascribes all to *Percussion* and *Protrusion*, must not think he has a Right to deny the Action of these Powers, because he can't comprehend the Manner after which Things thus happen; forasmuch as, according to such Notions, we might reject many Things likewise which Experience prove really to come to pass. Who can conceive the *How* of what has been shewn to happen about *Percussion*, or about the Operations of Light in *Contemplation XXIV*? How many Effects are there in Chymistry, as likewise in Hydrostaticks, of which we have not yet been able to comprehend the Manner how they come to pass? No more than of what has been said in *Contemp. XXIII.* about the Bodies and Roots of Plants, which perhaps would be as hardly admitted as this Doctrine of *Attraction* and *Repulsion*, if nothing must be believed to be true, but that of which we can understand the *How* and the Manner. Those therefore who make other Scruples and Difficulties, may consult the famous Writings of Dr. *Gregory*, Mr. *Whiston*, and others, who have illustrated the Physicks of Sir *Isaac Newton*, and allow of so many of the Arguments which are there used to demonstrate this *Attraction* and *Repulsion*, as they think do fully prove the same.

Now to shew briefly, that these two Powers of Nature are not supported by a mere Hypothesis, but that we see by Experience, that one Body is moved towards the other, and one Body driven from another, while no Man has ever yet been able to prove, by any satisfactory Arguments, any such Matter, to the protruding Faculty whereof these Effects can be ascribed : Let those who are not yet convinced thereof, observe another Property of Matter, namely, that all Things are heavy, or do gravitate and move towards the *Earth*, or *Center* thereof : After the same Manner also the Planets are carried towards the Sun, the Satellites or Moons towards their primary Planets ; and yet no Body has been able to shew to the Satisfaction of all, what has been the Cause thereof ; and even the Arguments that are produced to prove the contrary, do not want their Weight ; all which may be seen in the Works of the above-mentioned Gentlemen.

That which we have quoted in *Contemplation XXIV.* about *Light*, from Sir *Isaac Newton*, (which he says in his *Opticks*, p. 336, to be incomprehensible to such as follow the vulgar Hypotheses) is in p. 350 of the same Treatise so accurately solved by that Gentleman according to the Laws of *Attraction*,

traction, and confirmed by so many experimental Truths, that it would be very difficult, without supposing an *Attraction*, to discover any probable Causes of the same; besides this, Chymistry furnishes us with numberless Examples of such Motions in its *Effervescences* and Conjunctions of Bodies and Salts, and in its *Precipitations* or Separations of Bodies; both which do plainly represent an *Attraction* and *Repulsion*. The Causes, if there be any, among the Bodies that are near each other, we shall not here inquire into, and even Mr. *Mariotte* seems, in his Treatise of *Vegetation*, p. 15, to acknowledge such a Motion, which he calls a *Motion of Union*, and seems to understand thereby something analogous to this *Attraction*.

SECT. VI, and VII. *Gravity and its Effects.*

To come to the Particulars of some of these Laws of Nature:

One of those Appearances of Nature which are so familiar to us, that it is daily look'd upon by the most ignorant Men without any Surprise, namely, the *Gravity* of all Bodies, has often occur'd to me as an irrefragable Proof of a Wise, Powerful and Gracious GOD; and let him who has not yet been convinced by any other Arguments, seriously reflect with himself, whether it could have happen'd by mere Chance, and without any Design, that every thing which we call a Body, and which is to be found here upon Earth (for we shall not now take any notice of those things that are beyond it) falls, or is driven down with a certain Force, and by the shortest Way towards the Center of the Earth; and even when hindered by a resisting Power, or any other invincible Obstruction, still presses thitherwards, and oft-times with so great a Violence, that we see the Floors of Chambers, when loaden with too great Burdens, and even whole Houses sink down thro' the Force of such a Pressure.

And those who would deduce all these Effects from the Laws of *Percussion* only, must at least be convinced hereby (since such Pressures cannot be deemed compleat Motions) that there are other Laws that obtain in the World, and other Powers operating, than only those Percussions which proceed from *Local Motion*.

Particularly, that we may be convinced of the Direction of a Divine Providence, let us consider, *First*, what great things are brought about upon the Earth, by this simple Law of Gravity. By this alone it happens that the Globe of the Earth continues in its first State, and remains hanging upon its Center as upon nothing; that the Sea remains hanging upon its Bottom, which is heavier, and furnishes Men with all those Conveniencies we have formerly mention'd; by this Gravity Rivers flow, which would otherwise stand still, and be turn'd into putrifying and stinking Lakes; by this the Rains, Dew, &c. descend from the Clouds, and moisten the Earth, causing it to bear Fruits for the supporting the Lives of Men and Beasts, and providing Drink for all Creatures: 'Tis by this Gravity that Boats and Ships can sail upon Rivers and Seas, and that those Waters are disposed and rendered proper to bear vast and heavy Burdens upon their Backs; and whereby the Art of Men does produce so many agreeable Fountains and charming Cascades

Cascades that adorn the Gardens of Princes, and cause Brooks to run from Mountains, and Pumps to raise Water, and innumerable other Uses, that are owing only to the Gravity of Water: 'Tis this that causes Fire and Smoak to mount upwards into the Air, and puts in Action the Elastic Powers thereof, which if the lower Air were not pressed by the Weight of the upper, would, after having once dilated itself; remain so, and then all Things breathing would be immediately suffocated, even the Fishes, as we have said before, could not continue under Water without dying; nor could one only Particle of Water (of which there are so many Thousand in one single little Drop) ascend into the Air when the superior Pressure were removed; as also the Water kept up in the Clouds, being at once suddenly poured down, all Rain and Dew would cease from thenceforwards; and thus this beautiful Globe of the Earth, together with Men, Beasts, Trees, Flowers, and Herbs, would be abandon'd to a general Destruction: And if we were to reckon up all the Uses of *Gravity*, any one that is but the least versed in natural Inquiries, must be convinced, that it is no Hyperbole to say, that they would fill a whole Book.

SECT. VIII. *Convictions from the foregoing Observations.*

To conclude; Certainly an Atheist must be very unhappy, who pondering all these Things, and being taught by sure Experiments, and by this mere and simple *Gravity*, or rather by this only Motion and Tendency to the Center of the Earth, what strange Effects are brought about, is not able to discover that infinite Power which subjects all Things, all Bodies, from the very greatest to the smallest, and even the Particles themselves of Light and Fire to this Property; nor observe a Wisdom, which by this simple Law of Nature does with so much Ease, and so little Trouble produce Effects capable of exciting Astonishment in the most experienced Philosophers; finally, who perceiving, that among all the Events produced by *Gravity*, there are hardly any, or rather there are none at all, which do not contribute to his own, and all other Mens Happiness, yet cannot see the Goodness and Mercy of GOD therein.

SECT. IX. *Heavenly Bodies gravitate towards each other.*

BUT it is astonishing, what modern Observations have render'd very probable, namely, That this Natural Law of Gravity extends itself thro' the whole visible Universe, and seems to prevail over all, even over the great Heavenly Bodies, which gravitate towards each other in the same Manner as the sublunary Bodies seem to tend here with us to the Center of the Earth; upon which Foundation the whole Physical System of Sir Isaac Newton, who seems to be chiefly followed by the Great Men of this Age in many Things, is built. But I don't here undertake to found myself upon the bare Opinions of any Philosopher, forasmuch as they are often contradicted by others, so long as the Experiments are not only not uncontestably, but likewise not sufficiently known: I shall therefore only endeavour to represent some few of

those things that appear true by Experience, for the Instruction of those for whom we are here writing.

It is plain, by Experience, that all Bodies being once put into Motion, pursue their Way in one and the same Right Line, if they do not meet with any Obstruction, nor are turn'd out of their Way by another Power; so that whatever is moved circularly, as in *Tab. XXII. Fig. 1.* the Stone A in the Sling S A, being let loose, will pursue its Way according to the strait Line A F, which touches the Curve A H D E.

Now it has been proved by Observations, yea and admitted too, without any Dispute, by the most, if not at all the modern great Astronomers, that the heavenly Bodies, as A, (*Tab. XXII. Fig. 5.*) which they call the Planets, move about the Sun S, in a Curve Line A H D Z, which is not circular, but what the Mathematicians call an *Ellipsis*, at least comes very near to it.

And again it is plain, by what has been said, that a Planet being in any Point, such as A G, &c. of this Ellipsis A E D Z, would pursue its Way according to the Right Lines A F, or G I, which touch the Ellipsis at A or G, and so would entirely forsake the said Curve Figure, which it describes, were it not that another Power did continually cause it to approach or incline towards the Sun S, whose Force represents the Lines F G and H I, so that we see, that from the Course of each Planet, a plain Proof may be brought, that there is an active Force that attracts it every Moment to the Sun S.

Lastly, Experience teaches us, that the same Power of Inclination obtains not only in the great Planets that move about the Sun (*Tab. XXII. Fig. 1.* and 2.) with respect to the said Sun, but likewise in their *Satellites*; for Instance, in those of *Jupiter F*, and *Saturn H*, in relation to the same Planets, since these are commonly attracted to their primary Planets, after the same Manner as those Planets are attracted to the Sun, or exert a Motion by their Gravity towards the same.

SECT. X, and XI. *A strong Proof that the Heavenly Bodies gravitate towards each other, and Convictions from thence.*

BUT besides all this, I must not pass by a remarkable Observation related by Mr. *Whiston*, *Prælect. Phys.* p. 289. who shews experimentally, that besides this Gravitation or Attraction between the Planets and the Sun, and between the *Satellites* and their primary Planets, there may be visibly discover'd the like Attraction between one Planet and the *Satellites* of another. These are his Words, so far as they relate to this Matter.

For as Saturn H (*Tab. XXII. Fig. 1.* and 2.) remained some Years ago a long Time about its Conjunction with Jupiter F, (that is, when Saturn and Jupiter are at the nearest to each other, and we see from the Sun S, Saturn at V, and Jupiter at F, in, or almost, in a strait Line) and consequently it must necessarily follow, that Saturn, by reason of the Greatness of its Body, and its Nearness to Jupiter (for it is by both these that the Force of Attraction is regulated according to Mr. *Whiston*) must occasion some remarkable and visible Effects in the *Satellites*

of Jupiter, if that Planet with its Satellites be attracted to Saturn ; so the Matter is really ; and the Satellites of Jupiter do change their usual Course in this Nearness of Saturn, agreeable to the said Law of Attraction. So that even the so justly esteemed Astronomer, Mr. Flamsteed, who would not at first allow of this Attraction in the Heavenly Bodies, after having made the most accurate Calculations, did frankly confess, that this Law does likewise obtain among them in full Perfection.

Now let any one who hitherto has doubted of God's directing Power in the World, judge from these Experiments, whether there be not a wonderful Force acting upon these vast Globes (whose Magnitudes are not wont to be measured by Feet, Fathoms or Miles, but by whole Diameters of the Earth ; and whereof one, namely *Jupiter*, is equal to 8000 Globes of the Earth) which Power so violently protrudes those Bodies without any Instruments, that no Cannon Bullet can be compared to the Swiftmess of their Motion ; and at the same time does so direct the manner of these violent Motions likewise, without using any visible Means, that they are obliged (in spite of the unconceivably strong Efforts, which they incessantly make, to fly out of their Orbits) to obey the prescribed Laws of *Attraction* or *Gravitation* towards each other in every the smallest Point of their Way ; and thereby to determine their Motion within such narrow Bounds, even so far, that these Planets at a greater Proximity to each other, do, by the same Laws, continually depart farther from each other, and do render an Obedience thereto according to the most exact Rules.

Finally, After all this, let the unhappy Atheist consider, since all these Heavenly Bodies are driven or attracted with so dreadful a Force towards each other, whether it happens without Wisdom, that they having for so many Ages moved according to these Laws, have not at some time or another fallen foul or struck against each other in such a manner, as to burst in a thousand Pieces ; the rather, because even some of the principal Mathematicians maintain, that it is possible that notwithstanding the regular Motions ascribed to the Comets, they may yet run against the Globe of the Earth, and so produce a Percussion between two such swiftly moving Bodies, which no Body can think upon but with Terror : But of this last sort of Heavenly Bodies, since we know so little of 'em, excepting what is liable to Disputes, we shall make no farther mention here. This is certain, that unless an Atheist does absolutely deny his own Principles, and allows that an unconceivable Wisdom and Power, working without visible Means, has place in the World, he will live in a continual Fear that the like Misfortune may befall the Earth upon which he dwells ; for that these Laws according to which such great Bodies, none excepted, do continually endeavour to approach each other, can be ascribed to any other Causes than merely to the Will of the supream Director, does not seem to me to have ever yet been proved by any Body.

SECT. XII. *The Operations of Gravity in Bullets and Bombs.*

NEITHER Time nor Place will permit us to produce here any more of all those Arguments from *Mechanicks* or the *Science of Motion*, by which we could plainly prove a Directing Wisdom; since all the Motions of Bodies running against, or among each other, even to the very Smallest, are found to observe certain Laws, which could not proceed but only from an Understanding and Powerful Being, since they are regulated according to Reason and Judgment.

The aforementioned Gravity seems alone to give sufficient Proofs thereof in those Things which are every where observed among us upon the Superficies of the Earth.

And for greater Confirmation, what is there in the World more untractable, more ungovernable, than the Motion of the Parts of Gunpowder when 'tis set on Fire? And who could have imagined that those Motions in the discharging of Bullets from Guns, and tossing of Bombs from Mortars, do always observe the Laws of Gravity prescribed to them in their dreadful Force and Swiftmess, with so much Accuracy and Niceness, as to become on that very account the Objects of the Mathematicks? And yet we see that they don't move one Point forwards without continually obeying the same in their so swift a Course. And this Experience is even proper from whence to form fixed Rules in Gunnery and Bombarding, whereby Bodies protruded with so unexpressible a Force, in a Course so swift, as hardly to be restrained by any Powers, can be so exactly determined and regulated by the Design of Men, who have studied the Laws to which they are subject, as to be made to fall upon, or strike any particular Place, provided the same be within their Reach.

SECT. XIII. *The Operations of Gravity in the Catenaria, or Chain-Curve.*

WE could here produce numberless Cases in which it may be proved, that not only those prodigious flying Globes, such as Cannon-Bullets and Bombs, of which we have already spoken, but likewise thousands of Millions of others, and of the smallest Bodies, do describe Geometrical Curve Lines, wherein the Property of the Line, according to all the Laws of Mathematicks, is preserved in all its Points. Thus there run many thousands of Water-Particles out of the spouting Pipe of a Fountain, and not one of 'em shall transgress the Line which the Mathematician can shew that it ought to describe in those Circumstances. What Honour did that great Mathematician *Leibnitz* acquire, by shewing that he had attain'd to a perfect Knowledge of the Curve-Line *A C B*, *Tab XXIV. Fig. 3.* which is produced by the Gravity of the Parts of a Chain or Rope, fasten'd to two Nails, *A B*? And how much Esteem and Credit has it given to *Dr Gregory*, to have been the first Discoverer of some new Properties of the same? How many Mathematicians have in vain turned all the Powers of their Mind towards these Discoveries, who notwithstanding that they sufficiently knew the Properties of Gravity, which was the only true Cause thereof, yet are

forced to own, that they were unable to describe rightly upon Paper the *Catenaria* or Chain-Line, for so the abovesaid Curve is named? And who can contemplate without Astonishment, how nimbly the ignorant Parts of which this little Chain consists, do dispose themselves by their Gravity into that Order, which is requisite to produce the same? And thus we might give many more Examples of the same Nature.

SECT. XIV. *There can be no ignorant necessary First Cause deduced from a Series of ignorant Causes operating together.*

I KNOW very well, that those who set themselves as much as possible against a Knowledge of GOD resulting from the Creatures, will answer, that these Laws of Nature, according to which all these Things happen, and this Disposition of the Parts of the *Catenaria*, this Motion of Fountain-Water in its Course and Line, this Direction of Bullets and Bombs in their Flight, are always necessary, and that it would be impossible it should happen otherwise; and this they maintain to be the Reason that those Mathematicians, who argue justly, can draw Conclusions agreeing with the Premises.

For Instance, it is known that there is a Law in Nature, that in case two Powers do equally act upon a Body A (*Tab. XXIV. Fig. 4*) of which one acting in the Direction A K, and the other according to A L, would move the same Body: As the one or the other is more or less violent, that Body will be moved according to different Lines A D, A E, or A G, which are found and determined by drawing a Diagonal Line in the Parallelogram A B E F, A H G C, the Sides of which consist of the Lines along which the Body would be moved by each particular Power in the same Time, as here A B and A F, or A H and A C; from whence it then follows, that if in a Minute, or more or less Time, the Body A should be moved by one Power from A towards C, and by another Power from A to B, that the same Body A, by the Action of these two Powers, would equally in one Minute be driven, according to the Line A P, the Length A D, which is the Diagonal of the Parallelogram A B C D.

But in case the first Power could move the same not from A to C, but to F, in one Minute; and the Second Power remained the same, it might describe the Line A E in a Minute: In the like manner also, for the same Reason, if the Second Power that protrudes it towards A L, were greater, and could carry the Body in a Minute from A to H, if the First remained unchangeable according to A C, by both the Powers together, the Body A might in one Minute run the Space from A to G along the Line A G.

From which Principles Sir Isaac Newton has shewn briefly in his *Princip. Philos.* p. 14. and Mr. Varignon more largely in his *Nouvelle Mechanique*, that all the Laws of Motion, and the Rules of Mechanics do necessarily flow, and have given Instances thereof in all the Mechanical Powers.

It is likewise known, that the Flight-Line of a Bullet discharged from a Cannon, (*Tab. XXIV. Fig. 5. A D E F G*) is determined merely by this Law of Nature; forasmuch as there are every where two Powers acting upon it, *viz.* one, which being produced by the Force of Gunpowder, does continually impel it from A to K; and another, that of Gravity, which causes it to descend continually by the Lines A B, D L, E M, &c. which are at Right Angles with the Horizon.

SECT. XV. *The First Motion proves a God; as does also the Continuation and Communication of Motion.*

SINCE the Philosophers, whom we are endeavouring to convince, are wont to enquire into, and to prove the immediate Causes of all Things from their Effects or Operations only, why do they not more seriously endeavour to ascend to the first Cause of all Things? They find that the most, if not all the Appearances in Nature that have been hitherto known, are caused and brought about by Motions; whether we may call them Protrusions, or (with some other great Men of the present Age) *Attractions* or *Repulsions*; they enquire what Laws of Motions must follow from either *Percussions* or *Attractions*. Now let them extend their Studies to the Cause that first produced these Motions, and immediately the Power of a Deity will appear to them from Mathematical Conclusions, especially if they will please to reflect upon what Experience has taught them and all Mankind; namely,

I. That a Body may be put into Motion, and may likewise be at Rest, or cease from Motion; and that in both those Cases it will remain a complete Body, and preserve its Existence.

II. It follows from thence, that Motion does not belong to the Being of a Body.

III. Whereupon it may be here observed, that the famous Sir Isaac Newton, and the Commentator upon his Arguments and Demonstrations, Mr. Whiston in his *Praelect. Phys. Defin. I. p. 25.* (we Instance in both these Gentlemen, because no Body will dispute them the Title of very great Mathematicians) have rightly described or defined a *Body* to be an extended and solid Substance, not only indifferent to Motion and Rest, but likewise without any Power in itself, and simply Passive (*Substantia Iners & Passiva*) of which Mr. Mariotte gives a Proof by several Experiments, in the *Fifth Proposition of his Treatise about Percussion*, p 31. shewing, that how much more solid a Body is, that is to say, how much more of Corporeal Matter it contains within the same Space, so much greater is the Resistance which it makes against Motion.

IV. So that from all this it is easie to conclude, that no such Thing as a Body can be the first Cause of those Motions, which nevertheless we find to obtain among Bodies.

What can then follow, save only that the first Cause thereof must be incorporeal, and even wonderful and unconceivable in his Operations, forasmuch as not being a Body himself, he is able to move all Bodies.

Who is likewise the first Cause of every Thing that happens in the World; in which every Thing is performed by Motion; who is a Cause working freely, and according to his own good Pleasure, without any Necessity; because, tho' Motion cannot be made without a Body, yet tho' a Body exist, it cannot be proved by any Consequence that it must necessarily move; so that if it be endowed with Motion, the same must be deduced from a Cause operating without any Necessity.

Now this Cause must be infinitely Powerful, to be able to frame an Edifice of so vast an Extent as the Universe is, and to move such mighty Bodies as the Planets with so great a Velocity, as has been shewn above; he must likewise be infinitely Wise, since he is able to direct the Motions of numberless great and small Bodies to such glorious Purposes. This I think no Body who understands what has been already said can deny with more Reason than he can stily maintain, that a Ship can sail without a Rudder; that a Watch can shew the Hour without a Hand; that a Bell can sound without a Clapper, and so of many other Machines, that they are made without any Design. Now in all Matters where we can discover a determinate End and Purpose, it must be confessed, that a wise and understanding Being is concerned in the framing of them, since nothing that has no Knowledge can propose any End to itself. Finally, this Cause must be infinitely good, since by such Motion it imparts Life and Breath to all Animals, and bestows numberless other Benefits.

Besides all this, since it is here supposed that we have to do not only with a Sceptical Philosopher, but likewise with a Mathematician too, and who consequently, in order to support the preceding Objections, thinks himself capable to shew how the Laws of Motion may by a perfect Necessity be deduced from each other without any Divine Direction or Original; we intreat this Disputer, that he would only recollect the first Axiom, without which all Mathematical Argumentations would be in vain, and which therefore Mr. *Whiston* terms the most Fundamental of all, in his *Prælect. Phys. Mathem. Axiom the 1. p. 41*, and which likewise *Wallis* in his *Mechan. cap. 1. Prop. 11, 12. Huygens, Newton, Keil and Mariotte*, (the last of whom has endeavoured to render the same more plain by a particular Experiment) and many others have laid down for the Foundation of Mechanics; it is briefly this:

A Body being once at Rest, or in Motion, ceases not from that Rest, or from being moved in a Right Line with the same Force, and without any Augmentation or Diminution thereof, unless another Force acting upon it produces a Change therein.

This is allowed by every one, when a Body is at Rest; but when in Motion, 'tis doubted by many unexperienced Persons: But since our Philosopher is supposed to understand Mechanics, he must be likewise convinced of the Truth of this Law of Nature, since a great Number of Experiments have been made in Machines to confirm the same, by which this Law is with sufficient Certainty proved *a Posteriori*. And it will plainly appear to him whom we suppose to have read the Writings of great Men, what Pains they have taken in seeking after a satisfactory Cause of this wonderful Phenomenon, which will therefore be unnecessary to mention here; and that some of 'em have asserted

in exprefs Words, that the Almighty God is the only Cause thereof. See *Keil's Introd. p. 118.*

And if he ftill retains his Doubts, let him confider the following Law of Nature, according to which it has been allowed and experienced by every one, *That the Motions, and all their Differences and Changes in all Bodies are greater and smaller in Proportion as the Powers which impreſs the ſame on thoſe Bodies are greater or ſmaller.* According to this known Argument, that all Effects are proportionable to their adequate Cauſes: See *Wallis Mechan. cap. 1. Prop. 7.* So that if one certain Force cauſes one Motion, the ſame being doubled, will cauſe a double Motion, a triple Force, a triple Motion, and ſo on.

And let him ſuppoſe, that if a Man in the beginning of the World, or four or five hundred Years ago, had laid a little round Marble upon a Table, and to put the ſame in Motion, had given it a Fillip with his Finger; the ſaid Marble, according to the abovemention'd Law of Nature, would (if no other Force had oppos'd its Motion) have moved to this very Minute with the ſame Velocity in a Right-Line, and without ceaſing, would have continued to run in the ſame Line ſuch a Length, as no Man could determine the end of.

He knows that this is no vain Notion, but, as we have fully ſhewn before, a Law of Nature really obtaining in moved Bodies, confirmed by very many Experiments, and upon which almoſt the whole Science of *Mechanics and Percuſſions*, particularly the Properties of *accelerated and retarded Motion* are founded; Examples of which may be met with in the *Demonſtrations of the two fiſt Propoſitions of the Mechanics of Dr. Wallis.*

And let him farther confider with himſelf, if no Divine and Incomprehenſible Power had place herein, which cauſed the Continuation of this Motion, and which obliged all Bodies continually to obſerve a Law, that otherwiſe was neither to be believed nor underſtood; whether he could imagine that the ſmall and contemptible Force communicated by the Fillip of a Finger, could be the adequate Cauſe of ſuch a Motion, by which this little Body can exceed in its Courſe all the Bounds that he or any Man living is capable of preſcribing to it, without any loſs of its Force and Velocity; and whether any one beſides himſelf would ſay, that this ſo great an Effect can be accounted proportionable to ſo mean a Cauſe as the Fillip of a Finger; and if this does not ſatisfy him, if he be a Mathematician, he muſt know, *fiſt*, that no Body can be ſo ſmall, or move with ſo little Force, but that ſtriking againſt another, (which is at Reſt, and has no Obſtruction) how great ſoever this laſt may be, it will move it, and cauſe it to run forwards in a ſtrait Line, ſo that both of 'em will proceed with equal Swiftneſs; tho' ſuch Swiftneſs will be ſmaller than that which the fiſt moved Body was endowed with alone. [See beſides, concerning this Matter, *Wallis his Mechanics, Ch. XI. in the Scholium, Sect. II*]

So that from hence it follows, that when a little Body, not ſo big as a Marble, but ſo ſmall even as the fineſt Grain of Sand, being protruded by the Fillip of a Finger, runs or ſtrikes againſt another Body, which we will ſuppoſe to be as big as the whole Globe of the Earth, or if you will, thouſands
of

of times yet bigger (provided that neither of 'em be Elastical, and consequently rebound from each other) this great Body will not only be protruded together with such a Grain of Sand according to a Right Line; but unless some opposing Force or Obstacle do intervene, and hinder the aforesaid Motion, the great Body, as well as the little Grain of Sand, will by the Force of this Fillip, continue to be moved according to the said Line incessantly; and if they were to meet in their Way with a hundred thousand of other Bodies, and each of them were a Million of times bigger than the Earth, they would carry them all along with 'em in Consequence of this small Force, without any ones being able to determine how far.

Now that this, how wonderful soever it appears, is certainly true, no Mathematician can deny; but let this Sceptical Philosopher, who hopes by the necessary Deductions of one Law of Nature from another, to elude the Providence and Intervention of a GOD; I say, let him shew us from his Principles, whether he can any ways comprehend, not that such a thing actually happens (for this Mathematics will teach him) but how, and after what manner this Force of a little Grain of Sand so moved does act, so that any Percussion thereof does not only drive such unconceivable great Bodies with any Force, but likewise can continue the Motion of them without ceasing for thousands of Ages: And it has been long a Question in Physicks, *How the Motion of one Body is communicated or transferr'd to another?* Which as far as I know, has never yet been rightly answered by any.

Then in case he could make no other Reply thereto, than that both the *Communication* and *Continuation* of Motion, is something which indeed he sees daily happening, and in the same Cases; but that yet the most internal Essence of Motion is not so well known to him, as that he should be able to say, after what manner it passes from one Body to another; and notwithstanding what is accounted the visible Cause (as the Fillip, which in this Instance produced such a Motion in the Sand) has long ceased to exist; yet the Effect may last not only in its Form or Being, but likewise in the same Force, such a Number of Years, as no Man is able to determine; for to shew the Greatness thereof, it is well known to those that understand Mathematics, that according to this Law, a six and thirty Pounder being protruded out of a Cannon by the Force of the Gunpowder inflamed, would continue its Motion with the same Strength and Swiftness for thousands of Years, unless hinder'd by some other Force, notwithstanding that the Flame of the Gunpowder had ceased long before: Will he not then, even by this his own Answer, be compelled to acknowledge, that here, as before in the Motion of the Body itself, there is likewise an incomprehensible Power operating in the *Communication* and *Continuation* thereof?

SECT. XV. *The Reasons produced by some for the Continuation of Motion, seems too weak.*

I KNOW very well, that some great Mathematicians, who even confess that they can shew no Cause of this last Phenomenon of Divine Power, which maintains every Thing in its Existence, and by Consequence likewise this Mo-

tion of a Bullet in its Continuation, to illustrate the matter, affirm that a Bullet being once put into Motion will always remain so; just as a Square and a globular Body will always retain the same Figure; but I hope I shall be excused by them, if notwithstanding all the Esteem which I have for their Learning, I here add, that this Comparison, tho' produced with the best Design, which is to acknowledge God for the Cause, seems to me somewhat too weak, and not sufficiently analogous and proper: Since, *First*, tho' a Body being once turned from a square into a globular Figure, tho' it remains of itself globular, yet the lasting Operation of the globular Force does entirely cease: Whereas on the contrary, a Body that was once Still, and at Rest, being put into Motion, the lasting Operation of such moving Force will fully remain. *Secondly*, Since a Body cannot move of itself, being according to the Description of those Gentlemen, a *sluggish Lump of Matter*, and all Motion seems to require a Force which continually produces it; forasmuch as we see such dreadful Strength and Violence exerted by a Body once moved (as for Instance, by a Bullet shot out of a Cannon) which whilst it remained motionless, could not exert the least Force: So it seems to be a necessary Consequence, that a Body that has continued already a thousand Years in Motion, should not retain the same Motion for a thousand Years following, without a Power acting upon it, and producing farther Motion; whereas in order to retain a Circular Figure, there seems no farther Force to be necessary, than that a Body should at first assume such a Figure.

Nor is this opposed by any Mechanical Experiments or Rules; by which it plainly appears, that one Body running against, and striking upon another, which other is at Rest, both of 'em will continue moving with equal Swift-ness in a Right Line, till some other Power shall cause a change therein; but it is not maintained nor demonstrated, that with the Continuation of this Motion, the Power that protruded the Body, does not remain constantly acting.

Now which soever of these be true, it is sure enough, 1. That this Communication and Continuation of Motion are both obscure and entirely un- conceivable, as to the manner of their Production. 2. That they are the Founda- tion of every Thing we are taught in Mechanics, and of all that happens in the World; insomuch, that nothing can scarce appear plain either in Mechanics or Physics, to such who have not inquired into the Laws thereof.

SECT. XVI. *GOD acts Reasonably, Incomprehensibly, and according to his own good Pleasure.*

I LEAVE it now to the Judgment of an Atheist himself, whether he must not confess and allow;

I. That there is a Power acting in Nature after a manner not to be com- prehended by him, tho' the Effects are obvious to every one.

II. Whether all Things are not brought about in the supposed Cases by meer natural and ignorant Bodies, according to the most regular Methods of Mathematics.

III. And

III. And consequently, whether there does not then appear a Power in this Universe, which acts not only Incomprehensibly, but likewise Rationally, that is to say, according to Laws reducible to right Reason, or otherwise, in shorter Words, whether he cannot discover a God in all these Things; who to the end that he may be found not only by those that seek him in his Works, but likewise by sceptical and irreligious Philosophers too, has impressed clear and manifest Tokens of his Incomprehensibility, and consequently of his Greatness upon the Origin of Physicks, and the very Laws of Nature; to the end that an Inquirer into the Knowledge of Nature, how diligent and penetrating soever he may be in many Matters, yet if he be careless in this one great Point, may, before he proceeds any farther, be armed against this Temptation, that has caused so many to wander and depart from true Knowledge and Wisdom; forasmuch, as because they observed the Necessity of Mathematical Consequences, and likewise that natural Things do always really adapt themselves to the same, they therefore began to imagine that all Things come to pass by a blind Fatality; but if they had seriously and properly attended at the Beginning to the first and earliest Laws of Nature, they would have been convinced of the contrary: For let 'em tell us, as great Mathematicians as they pretend to be, from what Consequence it can be necessarily deduced, that there must ever have been any Motion in the Universe; and why it might not as well have remained without any Action, and without any Changes, entirely quiet and at rest? And again, on the contrary, what Necessity there is that all Motion should not be so dreadfully swift and disorderly, that every Thing should be thereby destroyed and confounded?

Can any Body likewise deduce these Principles from any Laws of Necessity, that is to say, from Laws that cannot be exerted otherwise, nor otherwise understood? And yet this just Disposition of Motion is the very first Principle of all that is delightful, of all that is necessary, and of all that is wonderful in the World.

SECT. XVII. *Other Reasons against the Necessity of Natural Laws.*

ONE might alledge many Things to prove this; as for Instance, since all Bodies running or striking against one another (tho' they be hard or soft, provided they be not elastical) do either totally or partially lose their Motion; and falling upon an immoveable Obstacle, such as a Wall, and the like, remain perfectly still, without exerting any farther Force; which Laws are known to all the Mathematicians, and may be found in *the first Proposition of Percussion by Wallis and Mariotte*, p. 88. What Necessity is there that has prevented the Motion, whereby every Instant so many Millions of Bodies throughout the Universe strike against each other, from ceasing either totally, or in a great measure, in so many thousand Years? If it should be said that it continues, and is maintained, because the most and even the very hardest Bodies are endowed with an Elastic Force, by which a new Motion is communicated to other Bodies striking against them, as we find it true in several Cases; yet this farther Question still remains: What Necessity can the best Mathematician shew for Bodies being endowed with any such Elasticity especial;

especially since it appears, that there are so many Bodies that have no such Faculty in them, and consequently that it does not result from the Nature of Bodies? If it be supposed that this is brought to pass by what they call a *Subtile Matter*, (not to examine now whether such a Matter be capable to produce this Force, and even tho' we should grant it,) yet it is nevertheless plain, that if the foregoing Effect, or the Elasticity be a necessary Quality, the Cause that is alledged thereof, must likewise be necessary.

Now it is needless to shew, that the greatest Philosophers are not able to deduce this Motion of such fine Matter, as necessarily resulting from the Nature of Bodies themselves, (which are entirely unactive) or from any thing besides.

Moreover, since such a Body being driven against any Obstacle, which it cannot remove by its own Force, does presently lose that Force, together with its own Motion; what Necessity is there, that it should happen otherwise in the only Case of Gravity? So that when a Body, falling down upon another Body that stops it, strikes against the same, it ceases indeed to move any longer, but yet does by no means lose its Force, but oftentimes proceeds to press with so much Violence, according to the same Right Line or Direction, that we see thereby great Bulwarks, Walls, and the like, overturned thereby; and tho' as many Causes thereof should be alledged, as there are particular Hypotheses, who can prove, that the said Causes do necessarily result from the Nature of Bodies?

So that if indeed we could continually and properly trace them back from Cause to Cause, we should unquestionably find that the first, which is the Spring of all the rest, acts without any Necessity, both as to the Things themselves, as also to the Manner thereof.

For which Reason, the Wisdom that appears in these Operations, and the Power being joined together, we need not search any farther for a Great, Glorious, and Adorable GOD; who, to the end that all Men might be convinced that the true Original of all Things which happen in Nature, is only to be deduced from his infinite Perfections, has deposited, and does still preserve the undeniable Proofs thereof in the first Natural Principles of all Things.

SECT. XVIII. *The Proof of a God from the Motions of the Particles of Light.*

BUT to turn into the Way again from this Digression, which yet was, in some manner, necessary to convince some unhappy Mathematicians, not so much of their preposterous Ways, as of their Neglect and Omission in justly reasoning about the first Cause of all Things; let us then pass on to other Matters, and produce one Proof, (which will appear undeniable to all Persons,) of a GOD directing every thing even to the smallest Particles and Atoms, as we shall shew from the Motion of the same.

How many Millions of Millions of the Particles of Light do issue in one Instant, from the Flame of a Candle? How much, yea, how unconceivably swifter are they than a Cannon-Bullet? Concerning which the Reader may consult the XXIV and XXV *Contemplations*; and if we would see how exactly they

they obey the Rules prescribed to them, in all their Number and Velocity, let us suppose the Flame of a Candle at *A B*, (*Tab. XXIV. Fig. 6.*) and hold with one Hand a common Spectacle-Glass at *G L*, at a pretty good Distance from the Candle, and with the other Hand a white Paper at *f h*, just behind the Glass, which being carried backwards to *e d*, you will meet with a Place, as *a b*, where you will see the Light which at first appear'd confusedly upon *f h*, representing perfectly and distinctly the Flame of a Candle inverted.

Now we know that this exact inverted Picture at *a b*, is occasioned no otherwise than that the Rays coming from the Point *A*, and making the Cone *A G L*, after having passed through the Glass *G L*, are all collected at the Point *a*, as those from the Point *B* at *b*, from *C* at *c*, and so those that come from all the Points of the Flame are all collected in so many Points upon the Paper at *a b*, and there cross each other; for which Reason the Pictures or Images, at *f h* and *d e*, remain wholly confused; because the Rays coming from a Point of the Candle, as *A*, upon that Place, do fill a large Space, and are mixed with one another, as has been shewn before.

This being done, and the Course of the Light understood, let any Man whatever cast his Eyes upon this Figure, and observe in what a vast Number the Particles of Light run, and are mingled with each other, just before the Glass; so that all the Cones of Rays *G A L*, *G B L*, *G C L*, and others that have their Tops or Vertices in each Point of the Flame, as *A*, *B*, *C*, &c. (of which there are but three represented here, tho' they be numberless) do compose a confused Heap of an unconceivable Number of Particles of Light at *m n*, before they come from the Flame upon the Glass; which Particles run an infinite Number of Ways obliquely and transversly among one another, as they fly towards the Glass: Let him likewise farther consider, how many thousands of Percussions will happen in that Place among the said Particles of Light flowing with such an amazing Swiftmess, and how many of 'em seem thereby to be driven out of their Way: In a word, let the greatest Philosopher tell us, whether this Motion of the Particles of Light, among each other can seem to him like to produce any thing but the greatest Confusion.

Now if one should endeavour to make an Atheist, who had never seen this Experiment, conceive all these Things, and if some Body should tell him, that all the Rays proceeding from each Point of the Flame *A*, *B*, *C*, &c. tho' mix'd together between *m n* and *G L*, having passed thro' the Glass *G L*, should again be mingled at the other Side of the said Glass, between *G L* and *f h*; and notwithstanding all this, be afterwards distinctly collected in just so many other Points, *a*, *b*, *c*, &c. in so exact an Order as to represent the Figure of the Flame *A B* (save only that it is inverted) in all its Circumstances at *a b*, better than the best Painter in the World; I say, if one should tell him all this, would he not look upon it as the greatest Impossibility? But if now one should convince him, that the same is experimentally true, and that these many Millions of Particles of Light, so swiftly moving among one another, do, without Delay, and after such an amazing Manner, submit themselves to this Law, as often as any one holds a Glass between the Candle *A B*, and the Paper *a b*, tho' they themselves are not only entirely igno-

rant of any such Law, but likewise of their own Motions and Crossings; let him seriously reflect, whether those Principles upon which he founds his unhappy Philosophy, can prove to his Satisfaction, that this does happen without the Direction of an Omnipresent Power, extending its Care over all Things, even the smallest of Bodies.

Let him consider after all this, whether he cannot discover a GOD herein, who to the End that those that despise and deny him should remain inexcusable (at least all such as understand the Motions of Light) has been pleased that they shall never open their Eyes without meeting and receiving an irrefragable Proof of a Wonder-working Deity, which so directs and regulates the unconceivable Multitude of all the Rays of Light flowing from all Parts, and mingling among each other, and seeming capable of producing nothing but an irretrievable Confusion before the Pupil of his Eye, as it was before the abovemention'd Glass, I say, does so regulate them all, that they can serve for a distinct Sight to all Creatures.

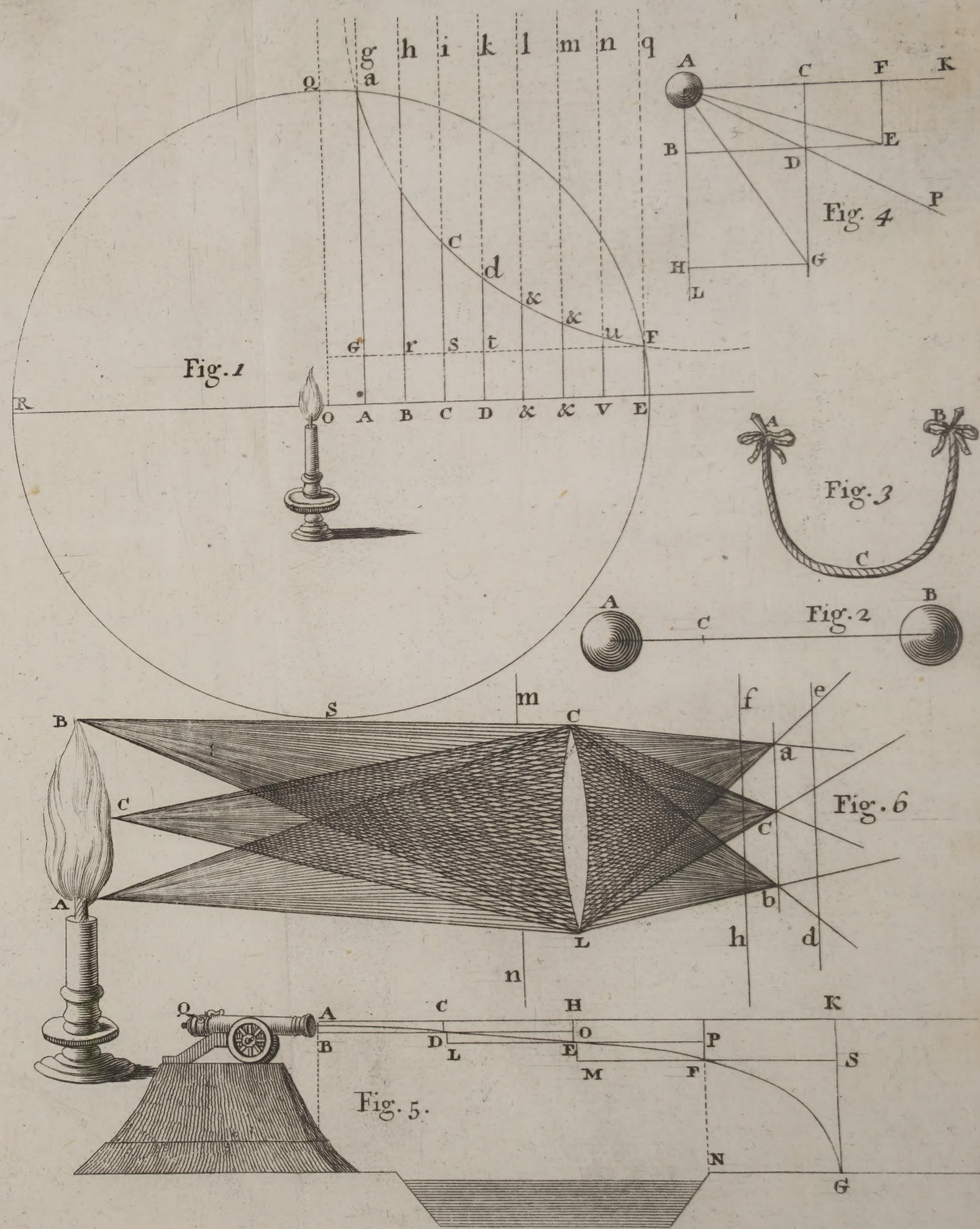
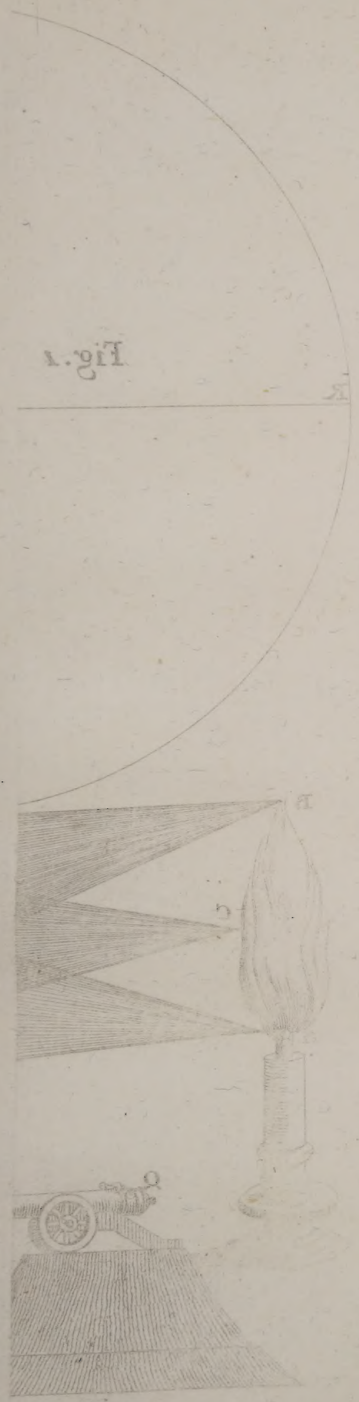
SECT. XIX. *The Existence of a God proved likewise from the Laws of Mechanism in general.*

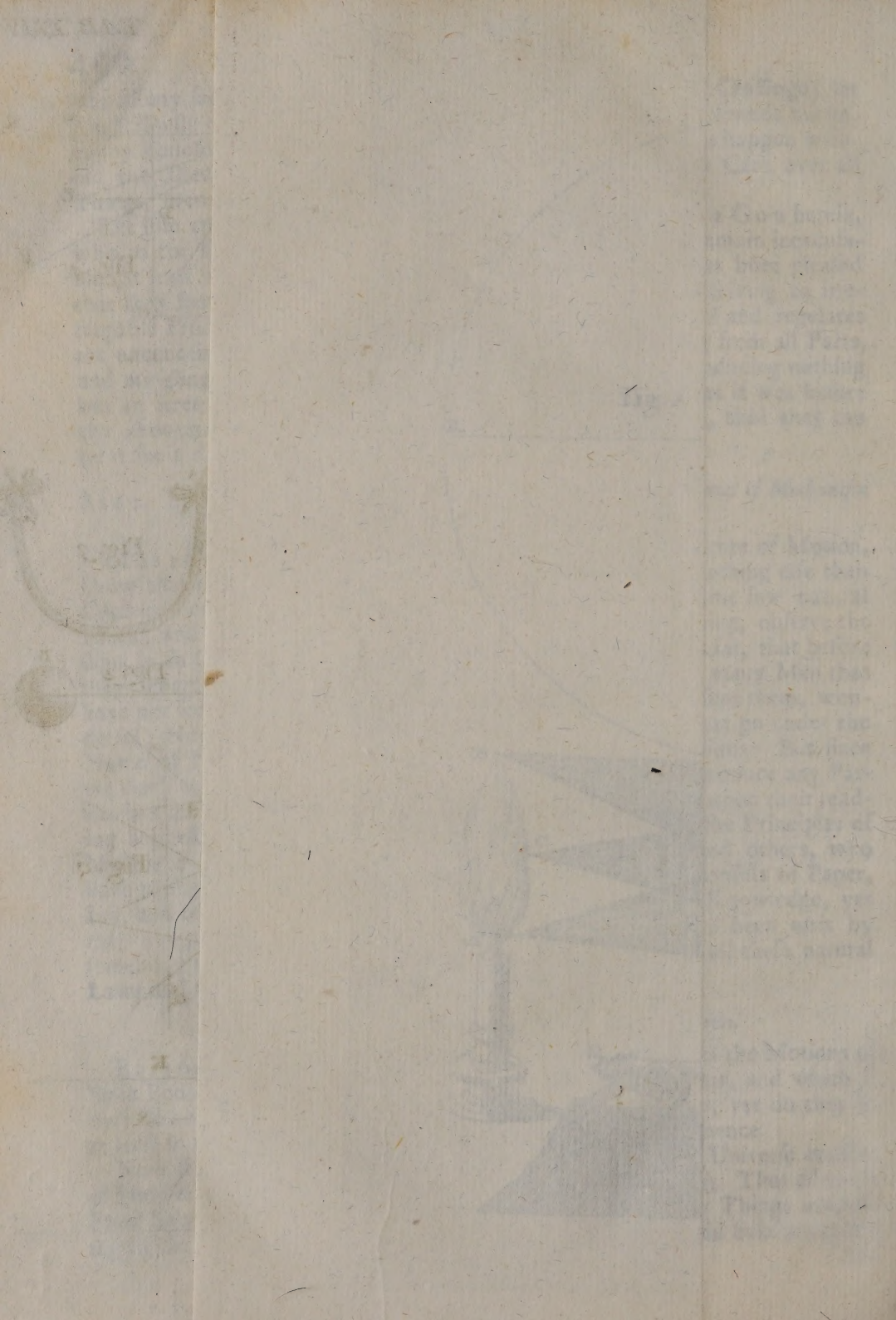
MOREOVER, all who understand Mechanics, or the Science of Motion, know that the same in its greatest Extent, does consist of nothing else than Consequences that are deducible by Argumentation from some few natural Laws; and that Bodies wholly ignorant of what they are doing, observe the same in all Circumstances with the utmost Exactness, even so far, that before they depart from the same, they operate Things which to many Men that have not seen them, seem incredible; and to those that have seen them, wonderful; Numbers whereof are to be met with in the Books that go under the Name of Natural Magic-Books, and Mathematical-Recreations: But since we don't write here only for Mathematicians, we shall not produce any Particulars thereof, but only ask those who still doubt, whether upon their reading a Book of any learned Author, in which are contained the Principles of Mechanics, (for Instance, that of *Stevin, Wallis, la Hire*, and others, who have writ particularly upon that Subject) tho' such a Book consists of Paper, Ink, and other Materials, in which there is neither Sense nor Knowledge, yet they will pronounce, with great Assurance, that it must have been writ by somebody who was Wise and Learned, and that understood all these natural Laws and their Consequences.

SECT. XX. *Transition to some Hydrostatical Laws.*

BESIDES the Laws by which the Great Director regulates the Motions of Solid Bodies, there are others that have place in Fluid Matters, and which if they do not very much differ, even in the first Fundamentals, yet do they so at least in the Phenomena, or Appearances, resulting from thence.

Now since we know, *First*, that the greatest Part of the Universe consists of Fluid Substances, such as Water, Air, Light, &c. *Secondly*, That all these Fluid Substances are heavy, and consequently produce many Things according to the Laws of their Gravity. *Thirdly*, That these Fluid Substances are the





the principal Instruments of which the Director of all Things does mostly make use. *Fourthly*, Since in this Operation of Fluid Matters, the Wisdom, Power, and free Pleasure of the Creator of the World does shine out after the clearest manner:

We shall proceed to a short experimental Demonstration of some of the said Laws of *Hydrostatics*, to the end that when we proceed to speak of the *Law of Pressure according to the Depth*, which has Place in Fluids, and from thence deduce so many Wonders of the great Ruler of Nature, any one may be entirely convinced of the Certainty thereof; which Demonstrations, those Readers who think they stand in no need of such Assistances, may pass by, and go on to what follows them.

Experimental Demonstrations of the Law of the Pressure of Fluids, according to their Height or Depth.

SECT. XXI. *General Terms and Positions in Hydrostatics.*

To begin then:

I. As to the Terms of *Liquids* or *Fluids*, we mean here the same thing by them, tho' some do not allow all Fluid Matters to be properly Liquid. For, according to them, the *Air* is indeed a Fluid Matter, but not Liquid, as Water, Oil, and the like: but for Brevity sake, we shall make no Difference.

II. All the Parts of a Fluid, when at Rest in a Vessel which is immovable, do yield to the smallest Force acting on them; and so yielding, have their Parts easily separated, which immediately by their Gravity do again come together. The Proof of which is obvious to every Man's Experience.

III. The Superficies of all Fluids, upon which there is immediately incumbent either another Fluid Substance, or nothing else that is heavy, or that operates by another Power, will, according to the Action of Gravity, become Horizontal or Level, that is, settle itself parallel to the Horizon.

In order to see such an Horizontal Superficies (which may also tend to make us the more easily apprehend some of the following Terms and Expressions) we need only pour into a pretty large Glass, first some Water, and then some Oil of Turpentine, for the Purpose; by which Means the Superficies of the Oil, and the Separation of those two Liquors, will shew the aforesaid Horizontal Plane; and the like will be obvious in almost all other Liquids that are unmixable.

We shall not here inquire whether the Superficies of a Stagnating Liquor be not likewise part of the Convex Superficies of the Globe of the Earth; but it is sure enough, that it may be suppos'd, without Mistake, that it does not differ visibly from a Horizontal Plane in so small a Space as we are treating of.

IV. I add moreover, that we do not here pretend, with some Mathematicians, to demonstrate every thing from Mechanical Principles; but only to shew Experimentally the Action of Pressure or Gravitation of Fluids, as they are govern'd by the aforesaid Laws of Pressure, according to their *Height* or *Depth*, that we may render them plain and intelligible to every Body, and even to such as are not conversant in Mathematics.

SECT. XXII. *The Order of the Experiments that are to be made for the Foundation of Hydrostatical Laws.*

TO proceed now, after premising these Things, to the Law itself of the Pressure according to Height, we can perhaps do nothing better, in order to be more plainly understood, and to give a true Conception of our Meaning, even to the most Ignorant, than to set before the Reader a few easy and not costly Experiments; for which Purpose I shall relate them just as they stand upon my Notes, taken about 16 or 17 Years ago, and in the same Order too, namely, That the first Experiments are made by one only Liquor, not so much because it is the usual Manner in which Philosophers treat these Hydrostatical Subjects, nor because Water, which is the Fluid commonly made use of for these Purposes, has no other Fluid Matter over or above it, since Air is always above, and presses upon it; but merely because these Demonstrations are more simple, and therefore more plain to Beginners, and that because the Air gravitating with equal Force upon equal Parts of the Superficies of Water, this Liquor may be much more conveniently used and observ'd, than if any other Fluid Matter were incumbent on it.

The Second Sorts of Experiments do herein differ from the former, that they represent to us the Action of several Fluids upon one another.

SECT. XXIII. *Of Fluids in Curve Tubes of equal Bigness.*

BUT before we enter upon these Experiments, we shall premise what, among other Things, has been first found to happen in Curve Tubes of an equal Bore.

TO wit, That in order to cause a Fluid Matter in the Curve Tube AID, (*Tab. XXV. Fig. 1.*) to quiesce or stop at the Height AB, in the Side AI, and to hinder it from descending on account of its Gravity, you must fill the other Side ID, with the same kind of Fluid, up to the like Height. This is plain enough in itself, and the Experiment may be easily made.

SECT. XXIV. *An Experiment to show the great Force of the Gravitating Power of Water.*

THE first Experiment which was about the Gravitation of Water, was the following:

I. I put into a large Glass Vessel ABCD, (*Tab. XXV. Fig. 2.*) a Curve Tube YXQ, and a streight one Zt, after tying them in such a manner to a Piece of Wood that lay a-crofs, or horizontally upon the Rim of the Glass, not only as to make Right Angles, but likewise that their lowest Orifices, PQ and rt, which were of equal Bigness, were equally deep, that is, stood in the same Horizontal Plane LM.

Then pouring Water into the Vessel as high as to *ab*, we might perceive the Water in both the Tubes to rise up to *de* and *nm*; and as far as it appeared to us, it ascended as high in the Tubes (which were chosen large for that Purpose) as it did in the External Vessel.

II. Now forasmuch as the Water could not of itself rise as high as de in the Curve Tube YXQ , nor remain suspended there, unless a Force press'd it down at PQ , as appeared, because upon stopping the said Tube with one's Finger at Y , and lifting it out of the Water in the Vessel by the Piece of Wood EF , if we removed the Finger from Y , we saw that the Water did not only not remain at de , but subsided to uw , driving out that which stood in its Way at the Orifice PQ .

III. From whence therefore it was obvious, that whilst the Tube was in the Water, a Gravitating Power acted upon the Part PQ of the Horizontal Plane LM .

IV. Now to inquire into the Properties of this perpendicularly Gravitating Force:

It appear'd, *First*, that the Force which press'd the Part PQ of the Horizontal Plane LM , did by no Means regulate itself according to the Surface or Breadth of the Water ab , nor yet to the Quantity of the whole Mass of Water $abLM$, which was incumbent upon the Horizontal Plane LM , of which PQ was a Part; of this we assured ourselves, by putting the Tube YXQ as low as de , in a much larger Vessel; for Instance, in a Bucket or Tub; in which Case we found, that notwithstanding the greater Breadth, when the same Depth of Water was incumbent upon PQ , yet the Pressure upon the Part PQ was not greater, since it could not cause the Water in the Tube to rise higher than to de .

V. It appear'd, *Secondly*, that this Gravitating Force upon PQ , adapted itself most nicely and exactly to the Depth of the Water aL , which was the Column of Water incumbent upon PQ and LM .

For pouring gently some Water into the Vessel, till it ascended on the outside of the Tube to AB , we likewise observed the Water within the Tube to rise from de to RS .

But on the contrary, when by sucking or letting out some of the Water out of the Vessel, it was reduced to the Depth of ab , or lower, the internal Water did also subside to de , or yet lower, but so as always to continue of the same Height with the External.

VI. Now it has been shewn before, and it also follows from *Seet. XXXIV.* that if the Curve Tube YXQ were extended from PQ to NO , or higher, and then fill'd up to the Height of gh or ab of the Vessel, the Pressure of this Column of Water $PQhg$ would be great enough to sustain the Water in the other Shank of the Tube to de .

VII. So that we may conclude from hence, that the whole Mass of Water in the great Vessel $aLMb$, does not gravitate more or less upon PQ , than this same Column of Water, $PQhg$, but precisely as much.

VIII. Now since this Column $PQhg$, is equal to a Column whose Basis was the Part PQ of the Horizontal Plane LM , and whose Height is the perpendicular Height Pg or Qh (or otherwise La or Mb) or the Water incumbent from ab upon the Horizontal Plane LM ; a famous Proposition in Hydrostaticks is deducible from hence, namely, That if we suppose a Horizontal Plane passing thro' a stagnating or quiescent Fluid, the Force whereby

a Part thereof, as PQ , is gravitated upon, or press'd down, is equal to the Weight of the aforelaid Column $PQgb$, whole Basis is the Area of PQ , Part of the Horizontal Plane LM , and the Height of which is aL , or Mb , or the whole Height of the Fluid incumbent upon the said Horizontal Plane, measuring the same directly upwards.

IX. This Column, because it extends itself from the suppos'd Horizontal Plane to the uppermost Superficies of this single Fluid, (and, if there be more Fluids incumbent on each other, to the uppermost Superficies of that Fluid which is highest,) and contains all the perpendicular Heights of all the Fluids impressing or incumbering on each other, we shall hereafter, for Brevity sake, call the Column of *Altitude*.

X. Now to shew that there happens not only to this one, but to all equal Parts, as PQ , of the same Horizontal Plane LM , one and the same Pressure, and each equal to the Weight of this Column, we remov'd the little Piece of Wood ET , with the Curve Tube YXQ that was tied to it, from one Part of the Vessel to the other, so that the Orifice PQ fill'd at every Turn a new Place of the said Horizontal Plane, but we always found the Water stopping at de , or at the same Height; and consequently, that every Part equal to the Area PQ of a Horizontal Plane LM , is always press'd down with an equal Force, which is also equal to that of the Column of Height.

XI. And to shew farther, that the different Figures of Vessels did not alter the Case, or that it is not necessary that this gravitating Column $PQbg$, should be always directly perpendicular to the Part PQ that it presses, we thrust a Piece of Wood, IK, GH , with a flat Bottom GH , or a Beer Glass, or a Phial with the Bottom downwards, to a certain Depth, as GH , under the Superficies of the Water ab , and held it there immoveable; after which we turn'd the Tube YXQ quite about, bringing the Orifice PQ to pq , directly under the aforelaid Bottom, and we observ'd, that notwithstanding the gravitating perpendicular Column over pq , could not extend itself higher than to GH , yet the Water remain'd in the Tube at de , and consequently at the same Height, as if the whole Column of Altitude $PQbg$, were supported by or rested on PQ .

XII. So that it appear'd from thence, that each Part PQ, pq , &c. of the Horizontal Plane LM , was not always just press'd by the Column of Altitude itself, but by a Weight equal to that of the said Column; and consequently that this Law obtains in Vessels of all Figures, of which, tho' there be here but one single Instance given, and numberless Vessels might be propos'd for Trial, yet it sufficiently confirms our Position with the Concurrence of all that are vers'd in *Hydrostatics*, and abundance of Experiments in all Kinds of Vessels.

XIII. I must however endeavour to remove one Difficulty, which it may be renders what we have just now said obscure to some People, and then pass on to somewhat else.

It is this, If a Drinking-Glass or Cup $k l 7 8$, be filled with Water, and then inverted suddenly, so that the Mouth $7 8$, descends below the Superficies

ficies ab ; and if one continue the Cup or Glass in the said Posture, it will be found,

First, That the Water will descend either to kL , or cf , according as there was more or less of it in the Glass, but by no Means so low as g or io , or as the external Water ab .

Secondly, That in case the Curve Tube YXQ , in which the Water is at the Height of de , be turn'd about in its String, and shov'd forwards, if necessary, with the Piece of Wood EF , so that the said Tube YXQ be brought to 146 , and its Orifice PQ to 56 directly under the Glass $kl78$ (continuing still in the Horizontal Plane LM) we shall find that the Water will remain in the said Tube immoveably at 23 , the same Height as de , and as the external Water ab .

Now since each Part PQ and 56 of the Horizontal Plane LM is press'd by the Column, the Height of which is equal to the Height of the Water; and forasmuch as there is no more Weight upon PQ than the Column $PQbg$, and since there seems to be incumbering on 56 a Gravitating Column $56fc$, of a greater Depth, and consequently of a greater Weight than that of $PQbg$; it seems that it ought to follow likewise, that the Pressure upon 56 should be much greater than that upon PQ ; and therefore that the Water in the Tube at 146 , should ascend much higher than 23 or de ; but on the contrary, the Water at 23 , or de , continues at an equal Height with the external ab .

This Experiment would be a notable Objection against what we have advanced, were it not that all who are any ways vers'd in *Hydrostatics*, know, that what is said before, is only meant when there is no other gravitating Fluid upon the Water ab ; and that the Pressure of the Air which always gravitates upon the Water ab , is only the Cause here that the Water continues suspended in the Glass or Cup at cf . That in case no Air press'd upon the Water ab , the Water in the said Glass $kl87$ would not continue higher than the external Water ab or $g10$, tho' the Glass be inverted; as is well known to those that use Air-Pumps.

So that this Objection is properly of no Weight against what we have asserted, since we only treat of Cases in which the Pressure of the Air produces no remarkable Alterations, or at least, in which we may suppose them.

SECT. XXV. Experiments proving that Fluids press upwards.

XIV. To proceed now to the Pressure of Fluids upwards:

That in Water and other Fluids a Pressure upwards has likewise Place, may be inferr'd from many Water-Works and Fountains that throw up Water.

This will also appear by the strait Tube Zrt : For unless the Water at the Part rt of the Horizontal Plane LM were press'd upwards, it would not be possible that the Column $rtnm$, which lies upon the Superficies of the External Water ab in the Vessel, could keep its Station at nm , since it is continually press'd downwards by its own Weight.

To give then an Instance thereof: Stop the empty Tube Zrt with your Finger at Z , and thrust or put it down into the Water as far as rt , you will thereupon

thereupon find that the said Tube will remain empty from Z to rt or thereabouts; excepting perhaps, that by the Pressure upwards of rt , the Water may rise a little, or so much higher in the Tube than rt (if let down into a great Depth where the Pressure upwards is stronger) as the Force of the said Pressure can contract or squeeze together the Air which is in the Tube.

But in order to know with what Force rt is pressed upwards, you need only remove your Finger away from z the Orifice of the Tube, and so give a free Passage to the internal Air which is driven against the Finger by the Pressure of the Water from below, and you will find (in case the external Water be as high as ab , and the Tube be tolerably large, so that there be not too great an adherence of the Particles of the Water to the sides of the Tube, on account of its narrowness) I say, you will find that the internal Water will not only rise as high as the external Surface ab , or nm , but much higher at first, for Instance, up to TV ; and that it will afterwards fall down from thence below nm , and not till after some Vibrations up and down, continue at nm .

From which Motion, or Ascent and Descent of the Water in the Tube Zrt , it is plain that it is not only hinder'd by a Resistance from falling down, as if it were oppos'd by a solid Body at rt ; but that a real and actual Power obtains here, and operates like Weights in the Scales of a Balance, which do likewise fluctuate or dance up and down, before they arrive at a just Equilibrium.

Finally, this Force pressing upwards, seems to be fully proved by the following Experiments.

Take a crooked Tin Tube (*Tab. XXVI. Fig. 1.*) ADF , which is of such width at EF , as to be exactly cover'd with the Top or Lid of a little wooden Box $EGHF$. Put it down into a Vessel $NTCO$ fill'd with Water up to the Surface NO , and you shall find that the little Lid * $EGHF$, tho' much lighter than the Water, will subside like a Stone, and how deep soever it be placed in the Water, will remain immoveable on the Orifice EF of the said Tube, until the Water insinuating itself between the Lid and the Tube, raises itself upwards, or till filling the Tube to $1, 2, 3, 4$, the Air at $34EF$, raises up the said Lid.

Hence it is plain, that if a lighter Body than Water (for Instance, so thin a Substance as this little Piece of Wood) is not rais'd by a real Force pressing upwards, that it will by no means float, but subside like heavier Bodies. We shall show hereafter, that Water can even raise and cause Lead to float by the like Force; but what we have advanced, is sufficiently confirm'd by the present Experiments.

SECT.

* N. B. The best Way to make this Experiment, is to keep the Lid down with your Finger close to the turn'd up end of the Tube EF , till it be about an Inch or two under Water.

SECT. XXVI. *An Experiment to shew the Greatness of this Force pressing upwards.*

XV. FROM this Water suspended in the Tube Zrt (*Tab. XXV. Fig. 2.*) we may judge, *First*, of the Greatness of the Force pressing upwards at rt for Instance; for since there is one Force acting by a Pressure upward, and another by a Pressure downward upon rt , as has been prov'd before, it is plain, if the Fluid at rt does neither ascend nor descend, but remains at the same Point, those two Forces or Powers must be equal to each other; for if either prevail'd, the Water at rt would be moved according to the Direction of that Power.

Now since rt is prest downwards by the Column of Altitude $n m rt$, as is shewn before; it is plain that rt is also prest upwards by a Force equal to the Weight of this Column of Altitude.

This may be farther prov'd another Way.

Take a Tube, which for Convenience sake should not be too large, and thrust it down into the Water as far as $11, 12, rt$: Stop the Mouth of it with your Finger at Z ; then if you lift it up perpendicularly out of the Water, the inclos'd Fluid will remain suspended at $11, 12, rt$, as is known to those who try Wines; then put the said Tube again into the Vessel fill'd with Water up to ab , so as the internal Water $11, 12$, may be below the Surface of the external ab or nm , or else above the same.

If then you remove your Finger from Z , you will see in the first Place, that the Force which presses rt upwards, is greater than the Weight of the Column $rt 11, 12$; and that it will cause the Fluid to rise from $11, 12$ to nm , or to an Height equal to the external Water ab .

On the contrary, if you take away your Finger from Z , when the Fluid $11, 12, rt$ is up at TV , or higher than the Water ab , you will find that upward-pressing Force at rt , is less than that of the Column of Water $rt TV$, and consequently that the said Column will descend, notwithstanding the Force which presses upwards, as low as nm , or ab .

Only if you thrust down the Tube with the included Water suspended for the Purpose at nm , till the said nm be parallel with the horizontal Plane ab , or till the internal Water nm be of an equal Height with the external ab ; you will see, that upon removing your Finger, the Water in $rt mn$, will remain there without rising or falling.

From whence it may be inferr'd, that the Forces which prest upwards and downwards, are in this Case equal to each other; and therefore that a Part rt of the Horizontal Plane, as it is prest downwards with the Weight of the Column of Altitude $rt nm$, is likewise prest upwards in Stagnating Fluids, with a Force equal to the Weight of the said Column.

XVI. If now, upon removing the Tube Zrt fasten'd to the little Piece of Wood EF , and carrying it along all the Parts of the Horizontal Plane LM , the Water remains continually suspended in the Tube at nm ; it follows, that every Part of the said Plane equal to the Orifice rt , is prest upwards with an equal Force.

XVII. Now

XVII. Now that this Force pressing upwards, adapts itself exactly to the Depth, but by no means to the Breadth, nor to the Quantity of the Water standing above a Horizontal Plane, may be shown here, as it was before, by the Force that presses downwards. For if you pour Water into the Vessel till it ascends from ab to AB , the Pressure upwards will be proportionably greater at rt , and cause the Fluid in the Tube to rise from nm to TV .

But if afterwards you draw off so much of the Water in the great Vessel, as to bring it down from AB to ab , or lower, the Force pressing upwards, will proportionably lessen; and whereas it was able before to raise the Internal Fluids as high as TV , it can't now keep it up beyond nm .

Thus we see every Thing adapts itself to the Height or Depth.

And if you have a mind to make this Experiment with a Bucket or Tub of Water, or with any other Vessel greater or smaller than that we used, you will find that the Breadth or Surface of the Water makes no Alteration, nor will the upward pressing Force produce any greater or lesser Effect, than to continue the Fluid nm in the Tube suspended at the Height ab of the external Water.

SECT. XXVII *The Laws of Pressure upwards and downwards.*

XVIII. FROM all this it is easie to conclude, with respect to the upward and downward Pressure compared together, that

If we suppose a stagnating Fluid (*Tab. XXV. Fig. 2.*) a Horizontal Plane from L to M , a Number of equal Parts taken at Pleasure, such as PQ , rt , pq , nm , 56 , &c. each of these Parts

Being, *First*, press'd upwards with an equal Force:

And, *Secondly*, downwards, with one and the same Force as another, be it what it will.

Thirdly, (and which is of great Use in *Hydrostatics*) that one Part, as PQ , taken at Pleasure, is press'd with as much Force downwards, as another that is equal to it, as pq , rt , &c. likewise taken at Pleasure, is press'd upwards.

And also on the contrary;

That the first Part PQ , is press'd with as great a Force upwards, as pq , or rt are press'd downwards.

Fourthly, That the Force which presses each Part upon the other, is equal to the Weight of the perpendicular Column of the Fluid.

All which is plain enough from what has been said.

SECT. XXVIII. *An Experiment of the Pressure downwards of different Fluids upon one another.*

XIX. HITHERTO, like many others who write about *Hydrostatics*, we have only consider'd Water as a Fluid that has no other Fluid upon or over it. But forasmuch as there is another Fluid which is usually incumbent on it, namely the Air, and which in some Cases does often and notably exert its Power, as we have shewn above, *SECT. XIII.*; it will not perhaps be displeasing to such as have not been much conversant in *Hydrostatics*, if we should here consider some of the Properties of different Fluids lying upon each other.

The *Experiment* therefore which we made some Years ago for this Purpose, may be perform'd with all unmixable Liquors; as these two are in which we see Brandy that has stood a while upon Pot-Ashes, to which we may join Oil of *Turpentine* for a third unmixable Fluid. We only try'd the same with two, to wit, with Pickle or Water, in which there was as much common Salt dissolv'd as could be, and with Oil of *Turpentine*.

We therefore took two little Sticks, *cd* and *ef*, and bound them to a Piece of Wood *gh* (*Tab. XXV. Fig. 3.*) which, as in the foregoing Experiment, we placed upon the Horizontal Rim of a pretty large and deep Glass-Vessel, so that the said Sticks made right Angles with the Piece of Wood, and descended perpendicularly into the Vessel; to one of 'em we ty'd the Curve Tube *CGB*, to the other the Streight one *DEF*, in such manner, that the upper Orifice of each, *C* and *D*, was a good way below the Rim of the Glass-Vessel, and the lower Orifices *AB* and *EF* (which as the Tubes themselves were of about the same Size) were placed as near as possible in the same Horizontal Plane *HE*.

XX. Now to give a rough Notion of the Pressure of the Air; we pour'd some Pickle into the Vessel up to *HI*, which running into the Tube *BGC*, at the Orifice *AB*, ascended in the opposite Leg up the Height *kl*, being parallel to the external Liquor *HI*, and there it staid.

When we remov'd the Tube, as in the former Case, from one part of the Superficies of the Pickle *HI*, to another, we always found that the Liquor within the Glass remain'd unchangeably at *kl*.

From whence it appear'd, in case the Air gravitates, which we suppose here, that it presses upon equal Parts, such as *AB*, *ab*, &c. of the Surface of the Pickle with equal Force: Since otherwise, if the said Pressure were greater on some Parts, and less on others, the Fluid *kl* in the Tube, would have risen or fallen; if otherwise (which follows from what has been shown already) the Air in the Tube *CG* incumbent upon *kl*, and higher, does continually press upon the said *kl* with equal Force. But this by the way.

XXI. Having pour'd in more Pickle, up as high as *LM*, we found the Liquor in the Tubes to rise to *xy* and *z4*; or as in the first Experiment, to the same Height as the external Liquor.

But when we pour'd upon the said Pickle *LM*, Oil of *Turpentine* to the Height *NO*, the Liquor in the Tubes rose from *xy* to *no*, and from *z4* to *pq*; but remain'd below *ON*, or the Superficies of the Oil.

From whence we may infer, that a lighter Fluid like the said Oil *NOLM*, being incumbent upon a heavier, as the Pickle, produces a Pressure both upwards and downwards: Since *AB* must be prest more downwards to make the Pickle rise from *xy* to *no*; and *EF* with a greater Force upwards, to raise the Pickle from *z4* to *pq*, and keep it there suspended.

XXII. AFTER this we thrust down a Crane or Syphon with a long narrow Tube thro' the Oil *NOLM*, till it came below *LM*, or till it reached the Pickle; of which as we drew some part out, we observ'd, that the Depth of the same Fluid in both the Tubes decreas'd proportionably, falling below *no* and *pq*, but rose again as more Pickle was put in.

The same Thing happen'd upon taking out, and letting in again any part of the Oil NO.

And so did the last, with lifting upwards the Orifices of the Tubes AB, and EF.

From whence it appears, that in several Fluids incumbent upon each other, as well as in one alone, the Pressures which raise and fall the Parts of any Horizontal Plane in each of the Fluids, are likewise adapted to the Depths of the incumbent Fluids.

But they are no ways affected by the Breadth of Fluids, since it is sufficiently known to all that understand *Hydrostatics*, that in case the Height of the Fluids over AB and EF continues the same, the Effect would be the same; and the Pickle at *no* and *pq*, would continue at the same Height in Vessels of all kinds of Breadths.

XXIII. We likewise found, that if we carry'd the Orifices of these Tubes AB and EF laterally along the Parts of the Horizontal Plane of the Pickle HI (the same may be said of the Oil too) the Liquor in the Tubes preserv'd the same Depth or Height in every new Place upon the same Horizontal Plane, as was observ'd in the first.

From whence it may be concluded, as before, that all equal Parts of a Horizontal Plane, whether the said Plane runs thro' the uppermost Fluid, or thro' any other which has more Fluids incumbent on it, are prest upwards and downwards with equal Force.

SECT. XXIX. *Oil gravitates or presses on Pickle, in the same manner as Air does on Water.*

XXIV. To represent now in a short Sketch, how Air operates upon a Fluid below it; we need only pour in Oil, till it rises up to PQ, or above the upper Orifices of the Tubes C and D; which by that means running into the said Tubes, it will cause the Pickle within them to subside from *no* and *pq*, to *xy* and *z4*, or to an equal Depth with the external Pickle at LM, just as if the Air prest upon it.

SECT. XXX. *The Greatness of the Pressure upwards and downwards in several Fluids incumbent upon one another.*

XXV. Lastly, LET us again suppose NO to be the upper Superficies of the Oil. Now to show with how much Force every equal Part of a Horizontal Plane HI, such as AB, EF, &c. are prest upwards and downwards, when there are several Fluids incumbent on each other; we poured Quicksilver into the Curve Tube ABGC, till it rose to an equal Height in both Legs, namely, to AB, and *kl*. Then we poured into the great Vessel, Pickle as high as LM, and Oil of Turpentine as high NO, and so thrust down the Tube BGC thro' the Oil into the Pickle, as far as HI; and when all was quiet and settled, we found that the Quicksilver had subsided in one Shank from AB to TV, and risen in the other from *kl* to *rs*.

This remaining so, we filled another Curve Tube of equal Legs (*Tab. XXV. Fig. 4.*) 789, first below to a certain Height (as here also AB and *kl*) with Quick-

Quicksilver, and bringing forwards the Curve Tube CG B, *Fig. 3.* close to the side of the great Vessel, we measured with Compasses as nicely as we could, the Height of the Pickle U W above the Quicksilver T U.

We also pour'd Pickle into the other equal Leg'd Tube 7 8 9, *Fig. 4.* till it rose to the same Height as W U above the Quicksilver that was in it, equal to the Pickle in the Vessel. After which, measuring in the like manner the Oil in the Vessel at M O, we also pour'd Oil into the Equicrural Tube to the same Height W X; so that the Pickle and the Oil, as well in the said Tube, as in the Vessel, were both suspended at an equal Height above the Superficies of the Quicksilver T U.

I should add here, that in order to bring Pickle and Oil into the Equicrural Tube *Fig. 4.* to the same Height with that in the Vessel, you must take care you do not pour them in at first to the Height required; because the Tube not being very large, when that which sticks to the Sides at pouring in comes to subside, it will cause it to rise higher than in the Vessel. This may be obviated perhaps by first filling the Tube *Fig. 4.* and then by pouring Pickle and Oil into the Vessel. They that have a mind may make the Trial.

Afterwards having measured with Compasses the Height ru (which the Superficies of the Quicksilver rs in one Leg had above the Superficies T U in the other) in both Tubes in and out of the Vessel, we found the same Height ru to be equal in both.

XXVI. From whence we plainly perceiv'd, that all the Fluids incumbent on each other in the Vessel above T U, and consequently also above A B, did equally gravitate upon A B in the Vessel; and neither more nor less, than if the said Fluids had been in a narrow ascending Tube, each in its streight perpendicular Height.

For since the Tubes both within and without the Vessel (*Tab. XXV. Fig. 3 and 4.*) were about the same width; if the Side-Fluids in the broad Vessel gravitated more upon A B, than the perpendicular Column A B Y X in the Equicrural Tube upon A B, *Fig. 4.* it would follow, that the upper Superficies of the Quicksilver rs , in the Vessel, would rise higher above the former Superficies uw of the said Quicksilver than in the Equicrural Tube.

XXVII. The contrary of which being found to be true in all the Parts of a Horizontal Plane, as H I, where-ever the Orifice of the Tube A B is placed, it shew'd, that when Fluids are incumbent upon each other in a Vessel, supposing in one of 'em a Horizontal Plane, as H I, no Part thereof will suffer either more or less Pressure from all the incumbent Fluids, how broad soever the Vessel is, than of a Column A B X Y; the Basis of which is A B, and the Top of it reaching up to the upper Superficies of the highest Fluid N O; and this is what we have call'd the *Column of Altitude*.

XXVIII. Now as we have describ'd above the Column of Altitude in a Fluid, it may be concluded how the same is so plainly describ'd in this Case; to wit, that in several Fluids incumbent upon each other, the *Column of Altitude* consists of a Pillar, whose Basis or Bottom is A B, or E F, for Instance, or some part of a supposed Horizontal Plane H I, and whose Top is the upper Surface of the uppermost of all the Fluids that are incumbent upon each

other; as for Instance, B Z compos'd of the several Depths of the Pickle B W, of the Oil W X, and of the Air X Z (imagining that X Z extends itself to the upper part of the Air) in such manner, that each Height, as B W, W X, and X Z presses downwards with the particular Weight of every Fluid of which it is the Height.

XXIX. It should be observed here, that it is not necessary that each Part should be always prest with such a perpendicular Column, since $a b$ suffers the same Pressure, notwithstanding (if we suppose K to be a solid Body) that the Column directly incumbent upon $a b$, or $a b m i$, can't extend itself in a streight Line higher than to $m i$, provided the Surface of the upper Fluid be at the same Height as before; but the meaning of all that has been said is, that both $a b$ and A B are pressed with a Weight which is equal to the Column of Altitude, Numb. XXVII.

XXX. So that in order to inquire into the Nature of any Water-Works, with respect to the Pressure of the Water upwards and downwards, you may single out a part A B, Fig. 4. of a Horizontal Plane H I, upon or over which the whole Column of Altitude A B Z may be placed; or otherwise you may lengthen out the Horizontal Plane H I towards N or I, even beyond the Vessel that contains the Part A B, (Tab. XXV. Fig. 3.) upon which we seek for the Pressure, and moreover take an equal Part A B, (Tab. XXV. Fig. 4.) of the said Plane extended from I to B, on which the Column of Altitude may be set and represented, if we continue the Surfaces M L and N O, &c. of the Fluids incumbent on each other as far as W and X.

So that to know with what Weight $a b$, in the Vessel, is prest; it may be answer'd, with the Column of Altitude A B Z, which is represented in Fig. 4. out of the Vessel; of which Column B W is the Pickle, W X the Oil, and X Z 8 goes up quite to the Top, is Air.

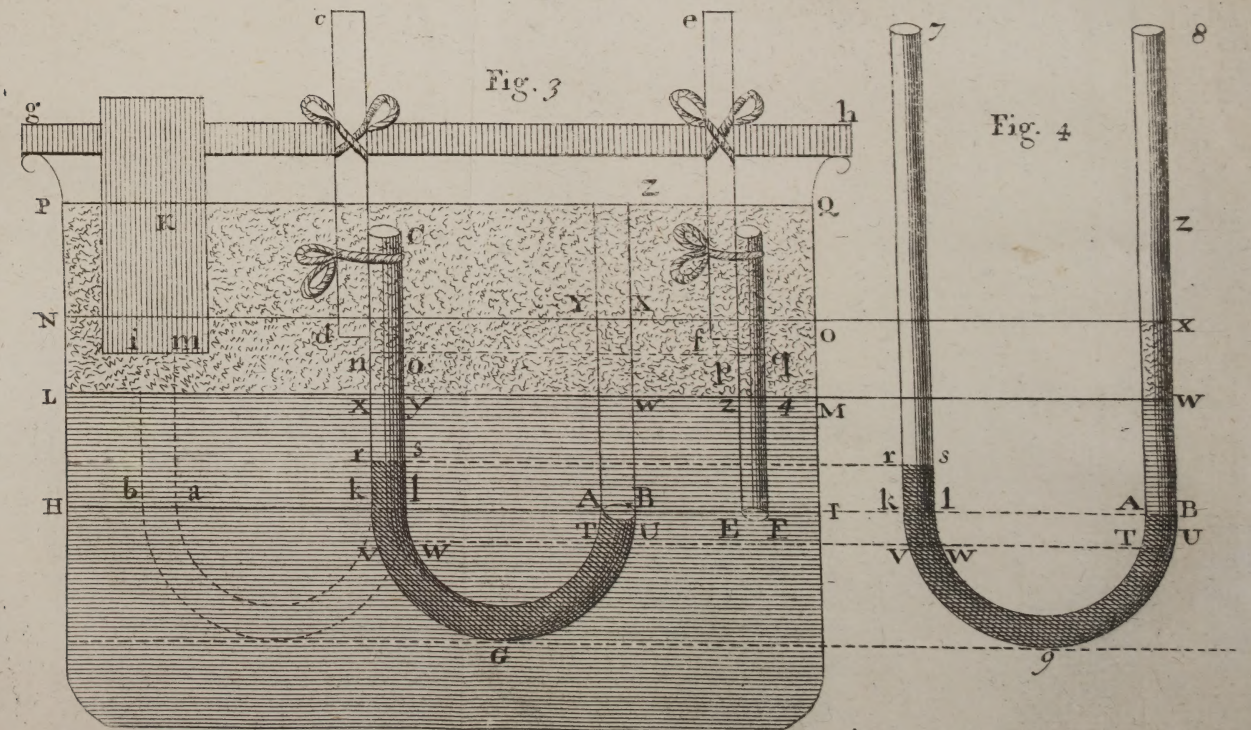
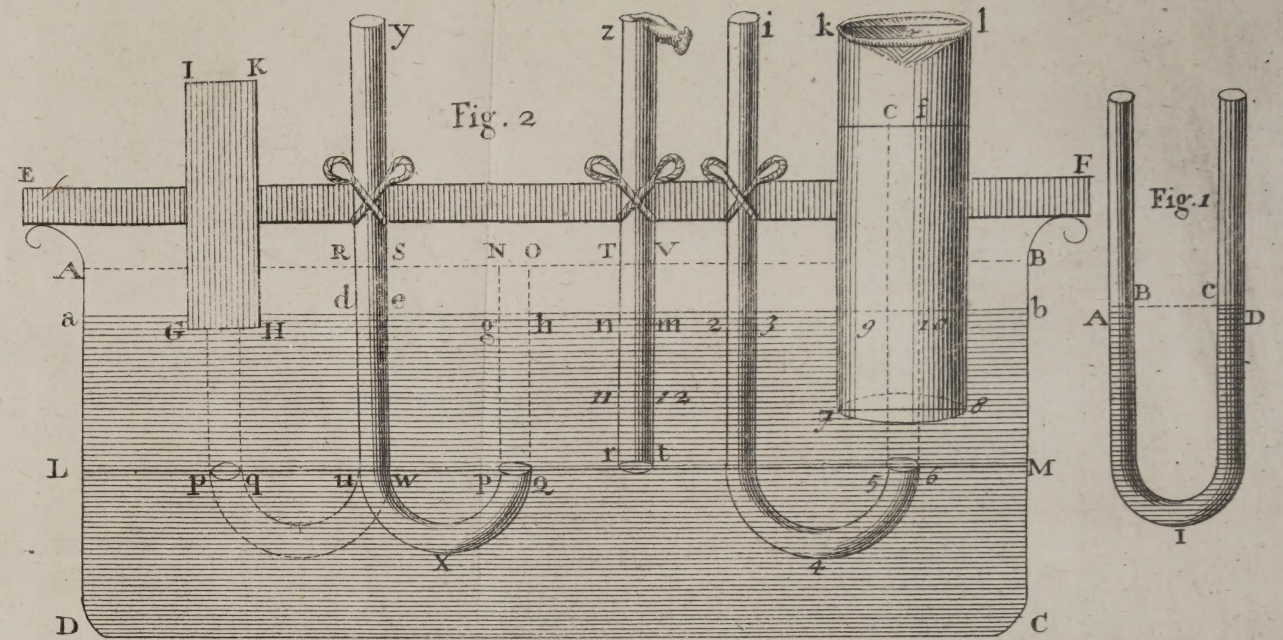
We might also conceive the Column $a b m i$ incumbent upon $a b$, as passing thro' a solid Body K, only by ascribing to the Height of each Fluid in it, its particular Part and Weight.

SECT. XXXI. *Of the Pressure upon equal Parts of Higher or Lower Horizontal Planes.*

XXXI. IT is unnecessary to add farther, that (Tab. XXVI. Fig. 2.) the Part d lying in the Horizontal Plane G T, is prest with so much more Force upwards and downwards, than the Part e in a higher Plane E F, as the Column of Altitude $f m$ upon G T, is heavier than the Column $f h$ incumbent on the other Plane E F. This every one may apply to a Part e in a lower Plane N H, as also to several Fluids lying upon each other.

SECT. XXXII. *Hydrostatical Laws of several Fluids incumbent on one another.*

XXXII. FROM all which then there follows this great Hydrostatical Proposition (which does likewise very much contribute to discover the Powers and Motions in *Hydraulics*, or Water-Works) after a short and plain Manner.



It is thus :

If several Fluids be incumbent upon each other, and we suppose one Horizontal Plane, as *HI* (*Tab. XXV. Fig. 3.*) passing thro' one of 'em :

Two or more equal Parts thereof (as *AB*, *ab*, *EF*, &c.) will each of 'em be press'd upwards and downwards with the Weight of their Columns of Altitude, and consequently with equal Force.

From whence it follows,

That one of these Parts, such as *AB*, is pressed downwards with the same Force as another *ab*, or *EF*, upwards.

And on the contrary,

That the first *AB* is pressed with as great Force upwards, as another *ab* or *EF* downwards ; which we shall therefore, for Brevity sake, call here the *Law of Altitude, or Depth*, because it adapts itself only to the Height (or Depth) of Fluids, but by no means to their Breadth or Surface.

XXXIII. It must be here observ'd, that in the Pressure upwards and downwards on equal Parts of the same Horizontal Plane (we do not now speak of higher or lower Planes) it is meant of such Parts *AB*, *ab*, *EF*, &c. which have a Communication with each other in the same Fluid ; that is, such as a Thread or Line, may be suppos'd to be drawn from the one to the other, without being obliged to pass thro' another Fluid or Solid Body.

It is necessary to lay down this Caution here, because this so general Proposition may otherwise not succeed in some Cases.

SECT. XXXIII. *The Pressure upwards proceeds only from Lateral Fluids.*

XXXIV. WE have no occasion to prove expressly, that all Parts, as *rt*, (*Tab. XXV. Fig. 2.*) of a Horizontal Plane *LM*, are press'd downwards by their own Weight, and that of other incumbent Fluids ; but that they are never press'd upwards, but by Fluids that are not only higher, but also lateral ; and other Parts of the same Horizontal Plane *LM* press'd downwards : So that all Pressure upwards proceeds from these Lateral Fluids, as from their nearest Causes.

For take away the Lateral Fluids that are in the Vessel *aLMb*, on the Outside of the Tube *rtTV*, the Liquor in the said Tube losing its Pressure upwards, will immediately subside.

SECT. XXXIV. *Oblique Pressures do likewise adapt themselves to the Height of Fluids.*

XXXV. Now to say something concerning the *Oblique Pressures* of Fluids.

That Fluids may be press'd and protruded in various Obliquities, is so plainly proved by the Cocks and *Ajutages* of many Fountains, as not to require any farther Demonstration here.

But that these oblique-pressing Fluids do also adapt themselves to the direct perpendicular Height of the said Fluids over the press'd Part, as the foregoing, and by no Means according to their Quantity or Obliquity, shall be likewise briefly shown.

Take a Recurve Tube (*Tab. XXVI. Fig. 3, and 4.*) A B C D, which being continued from C D, assumes the Form of C E F N D; pour Water into it up to A, whereupon you will find that the Water will spread itself till it attains to an equal Height in the other Leg E F, of whatsoever oblique Shape the said Leg C D E F be, with respect to the press'd Part C D.

Now we know, that if the Tube were extended from C D, streight up to C G H D, and were full of Water as high as G H, or at a Height equal to A L and E F, the perpendicular Column C G H D, would keep the Water in the Tube A B, to the same Height A B, just after the same Manner as here in the Oblique Pressure E F N D.

Consequently the Horizontal press'd Part C D, undergoes an equal Pressure from the streight Column C G D H, as from the Curve or oblique one C D F N D.

And this would be just the same, and remain so, though the Curve Tube (*Tab. XXVI. Fig. 4.*) were widen'd, as at C E F K D, or even narrow'd in any other Manner, so as to contain a greater or lesser quantity of Liquor; aslikewise in which Obliquity one of the said Tubes stood upon the Plane B C D, and press'd the Part C D; if only the press'd Horizontal Part C D preserv'd the same Magnitude, and the Perpendicular Height G C, H D, or F M of the Fluids upon the Plane C D continued the same.

SECT. XXXV. *The Hydrostatical Laws of Oblique Pressures.*

XXXVI. So that the foremention'd Law of Altitude, is here also of full Force in the Case of Oblique Pressures; and the following Proposition is true:

If a Part C D of a Horizontal Plane B C D, is press'd by a Curve or Oblique Column of Water C E F N D; the Pressure it undergoes is neither greater nor lesser than that of the Column of Altitude; that is, of the Perpendicular Column C G H D, which has for its Basis the pressed part C D, and for its Height the streight Perpendicular Lines F M, or G C, which are extended from the press'd Part C D, to the uppermost Surfaces A F of the highest Fluid, supposing there to be more than one.

SECT. XXXVI. *Lateral Pressures do likewise adapt themselves to the Heights or Depths of Fluids.*

XXXVII. It now remains to inquire into the Force of the *Lateral Pressure of Fluids*, whereby they are thrust or press'd along the Horizontal Line.

That this kind of Pressure does also obtain in Fluids, appears from the fitting or placing Cocks in the Sides of Barrels, &c.

Or otherwise, fix a Tube E F (*Tab. XXVI. Fig. 5.*) horizontally, or into the Side of a Vessel A B C D, fill'd with Water to the height M N, and you will see the Water gushing out in a Stream F G H; so that at E F it runs horizontally, and at F G H inclines or bends itself to the Earth.

And

And in order to know that this Lateral Pressure does also adapt itself to the Height, you need only fill the Vessel up to A B, so that there will then be a greater Height or Depth of Water E B above the Tube E F; and you will find that the Stream F I K gushes out so much farther, and horizontally to K; but that in Proportion to the Decrease of the aforesaid Height, by letting out the Water, the horizontal Force does also decrease, and continually incline nearer to the Vessel, as first at H and then at P.

Now that this Lateral Pressure does by no means adapt itself to the Breadth or Quantity of the Water, may be seen, if by continually pouring Water into the narrower and wider Vessel, such as A B C D (provided it be not too narrow) the Water be kept at the same height A B; for then in both Cases the Stream F I K will preserve the same Horizontal Line.

SECT. XXXVII. *The Method of discovering the Greatness of the aforesaid Pressure.*

XXXVIII. BUT now in order to compare the true Force of the Lateral Pressures with that of the Height or Depth of Fluids upon equal Horizontal Planes, as we have done in other Pressures, we must bestow somewhat more Pains.

For if we take a quadrangular Vessel (*Tab. XXVI. Fig. 6.*) A Q P K with plain perpendicular Sides A Q, and P K; and in it conceive the Part A E of the Side A Q, against which the Water, wherewith it is fill'd up to A K, presses laterally; and if you moreover conceive another Part E I in the Horizontal Plane O E, and equal to A E; it is clear that upon each Point F, G, H, I there is an equal Depth of Water *a* F, *c* G, *e* H, *g* I, and consequently that each of the said Points is press'd downwards with an equal Force; but nevertheless, that each of those Points B, C, D, E, in the perpendicular Part A E, suffers an unequal lateral Pressure; because, as we have shewn before, the lateral Pressure accommodates itself to the perpendicular Height of the Water, and so is greater or less accordingly; and each Point, as A, B, C, D, E, has a different Height of Water above it, or rather above the Horizontal Plane in which each Point lies.

Accordingly the Point A, or the Horizontal Plane A K, has no Height of Water above it.

The Point B, or the Plane B L, has the Height A B or *a b* over it.

The Point C, or the Plane C M, the Height A C, or *c d*.

The Point D, or the Plane D N, the Height A D, or *e f*.

The Point E, or the Plane E O, the Height A E, or *g i*.

So that from hence it is manifest, that in order to know how much greater or smaller Pressure the Horizontal Plane E I undergoes from the Water that lies in equal Height upon all its Points, than the Perpendicular A E, which has different Heights of Water over all its Points; that by reason of the great Difference of the Height of Water lying over the highest and lowest Points of the perpendicularly press'd Part A E; to avoid Mistakes, we must, *First*, inquire how much greater or smaller the lateral Pressure (for Instance) upon one of the Points B or C, &c. is, than the Pressure down-

wards

wards on one of the Points b or d , &c. which have the same Height of Water over them.

And, *Secondly*, when this is known in each Height a, b, c, d, e, f, g, i , that we compare the Sum of all these different lateral Pressures upon all the Points or little Planes that make up $E A$, with the Pressure downwards, which all the Points or equal Breadths compriz'd in $E I$, do bear together.

Thirdly, It is plain, that the smaller the Parts or Points are into which $A E$ and $E I$ are divided, the lesser is the Difference of the Heights or Depths of Water over the uppermost and undermost Points of the Part of $A E$, and consequently these Diversities of the Heights will produce the smaller Change in the Calculations, which, if these Parts were taken very large, might occasion great Difference; whereas they may be now safely enough taken, if we consider the Parts of $A E$, such as A, B, C , &c. as very small, and mere Points.

SECT. XXXVIII. *The Comparifon of the Lateral and Perpendicular Pressure of the Air upon an equal Part, fhown by an Experiment.*

XXXIX. To fhew the *First* experimentally, to wit, that the lateral Pressure which fuch a little Part as B , having a Height of Water, as $A B$, above it, undergoes in the Perpendicular $A E$, is equal, or at leaft does not fenfibly differ from the Pressure downward, which a horizontal equal Part b , that has an equal Height of Water $a b$ over it, fuffers from the incumbent Fluid, may appear from what follows, propos'd, if I miftake not, firft by Mr. *Mariotte*, but with another View.

Having try'd the fame in the Year 1696, and feveral times fince, I find among others, the following Remarks, which every Body elfe may alfo make by the help of the little Glafs Inftrument invented by Dr. *Muffchenbroek*, for the fame Purpose, with little Charge and Trouble.

We caus'd a little Hole $a b$ to be drill'd or bored in the Plane Side $V Q$ of a Bottle $A B P Q$ (*Tab. XXVII. Fig. 1.*) and another fomewhat bigger at the Bottom of the faid Bottle at P , which laft might be flopt by putting fomething into the Hole, and the Mouth $A B$ was flopt with a Cork $C D F G$, thro' which the Glafs Tube $E W$ was thruft, and the Joints were fo well cemented with *Emplaſtrum de Minio*, that no Air could pafs neither between the Tube and Cork, nor the Cork and the Mouth or Hole.

Then flopping the little Hole $a b$, and the Glafs Tube E with the Finger, we pour'd Water into the Veffel thro' the biggeſt Hole P , with a Funnel that had a very flender Noſe, till it aſcended to the Height $R T$, or higher than the little Hole $a b$, which otherwiſe requires no Bounds.

Moreover, having cloſ'd the Hole P with a Cork or a Plug, we thruſt a little Tube $a b g h$ acroſs in the Orifice $a b$, which Tube being ſhut, or hermetically ſeal'd at $g h$, had a Horizontal Orifice at $f g$, as that at $a b$.

Then ſetting the Veffel up an end again, and flopping the Orifice $f g$ with the Finger, we fill'd the Tube $E W$ almoſt to the Top with Water. After which I removed my Finger from $f g$, whereupon the Water ſpouted out

out of the said Orifice $f g$, and subsided in the Tube $E W$; but without producing any other Alteration or visible Diminution in the Height of the Water $R T$ in the Vessel, than what might be justly ascribed to the Contraction or Expansion of the Air incumbent on the said Water $R T$.

Finally, All being at Rest, it appear'd, that as the Water in the Vessel continued at $R T$, that in the Tube $E W$ stopt at $d u$, at the same Height with $f g$, or with the Horizontal Plane $d g$, which passes thro' $d u$ and $f g$.

Whereby we perceiv'd that the Column of Air $f g K$, by its perpendicular Pressure upon the Water at $f g$, could keep the same suspended at the Height of $d u$ in the Tube $E W$, and balance an equal Column of Air $d u H$, which was incumbent upon $d u$, according to *Se^{ct}. XLI, &c.*

Now to compare the lateral Pressure upon $a b$ with the perpendicular Pressure $f g$, we took the little Tube $a b h g$ out of the Hole $a b$, and found that every Thing continued in the same State, and that hardly any Water flowed out of the said Hole $a b$; the Water also in the Tube $E W$ remaining at the same Height $d u$.

For if it had fallen in the said Tube, but a Hair's Breadth, down to $e w$, by reason of the Difference of the Air's Height at a and b (which however was not observable) the same by making the Hole $a b$ smaller, would have dwindled to nothing.

XL. Supposing then that the Water in the Tube $E W$ did continue at the same Height, whether the Air press'd downwards upon $f g$, or a-cross and sidewise upon $a b$, without the little Tube $a b g h$, it was plain that the Air press'd with much the same Force by its Weight directly downwards, and laterally, or sidewise, when these press'd Parts $f g$ and $a b$ were taken so small that the Heights $I a$ and $I b$ differ so little.

SECT. XXXIX. *An Experimental Comparison of the aforesaid Pressures in Water upon an equal Part.*

XLI. BUT since the above-mention'd Experiment does only shew the Equality of these Pressures in Air, to the end that the same may be represented in some other Fluid, as Water for Instance, we placed the aforesaid Bottle $A B P Q$, with and without the Tube $a b g h$, in a Vessel of Water $L M N O$: So that the Water in the Vessel was as high as $L O$ above that in the Bottle, and we observ'd in both Cases that the Water in the Tube $E W$, rose and continued at $r z$ an equal Height with that in the Vessel $L M$, and consequently higher than that in the Bottle $R T$. So that the Water in the Vessel $L M N O$, whether pressing perpendicularly upon $f g$, or laterally against $a b$, exerted an equal Force and Pressure upon equal Parts, as $f g$ and $a b$, when taken small enough.

SECT. XL. *The Greatness of a Lateral Pressure upon a Plane.*

XLII. FROM whence it follows, that we may return again to our former Thread, and to *Tab. XXVI. Fig. 6.* and compute what a Force of Pressure a perpendicular Part $A E$ suffers laterally from the Water as high as $A K$ in the Vessel $A Q P K$, in Comparison of the Force which an equal

Part E I, lying horizontally, undergoes from the incumbent Water A E i g; we must first suppose the press'd Parts or Planes A E and E I to consist of other smaller Parts, or of very small Points, A, B, C, D, E, F, G, H and I.

Secondly, That each of these Points or little Particles B, C, &c. does sustain just as strong an Action from the lateral Pressure, as *b* and *d* from the Pressure downwards of the visible Heights *a b*, *c d*, &c. of their incumbent Water.

XLIII. Let us then for Conveniency suppose that A E alone does consist of five equal Parts, A, B, C, D, E, and E I of five Parts also, E, F, G, H, I: Tho' we should proceed more surely, if we supposed these Parts to be much smaller, and that A E as well as E I, did consist of some Thousands or Millions of the said Parts; forasmuch as then the Heights *a b*, *c d*, &c. of the highest and lowest Ends of these Parts would hardly be different, as has been already mentioned above.

We have however taken such a small Number as 5 here, it being so represented in the Figure, and because, whether the Number of the Parts be great or little, the Issue of the Calculation will be the same.

To come to it therefore; if it be supposed that the Height *a b* contains 1 Pound, that of *c d*, 2 Pounds, *e f*, 3 Pounds, *g I* 4 Pounds, and so on, if more Parts be taken, it has been proved before, that there is an equal Lateral Pressure upon the Point.

A, as downwards on <i>a</i> , and because there is no Height or Column	of Water incumbing on <i>a</i> , it bears	- - - - -	0
On B as on <i>b</i> , and by reason of the Height <i>a b</i> , the said <i>b</i> bears		- - - - -	1
On C as on <i>d</i> , and because of the Height <i>c</i> , it bears		- - - - -	2
On D as on <i>f</i> , and because of the Height <i>d f</i> , it bears		- - - - -	3
On E as on <i>I</i> , and because of the Height <i>g I</i> , it bears		- - - - -	4
So that the Weight which all the Points together bear, is		- - - - -	10 lb.
Furthermore: Each of the Points E, F, G, H, I, have incumbing on them a Height or Column of Water equal to <i>g I</i> , and consequently each bears 4 lb. which being multiply'd by 5, there being so many Parts suppos'd in A E and E I, the whole E I bears			20 lb.

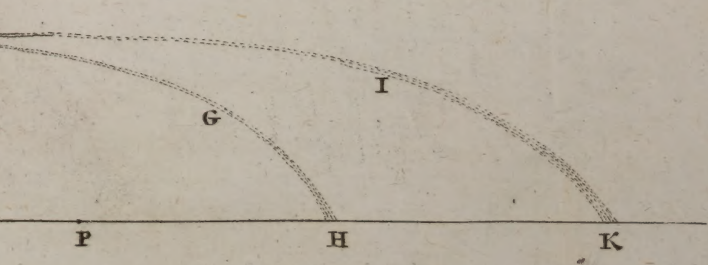
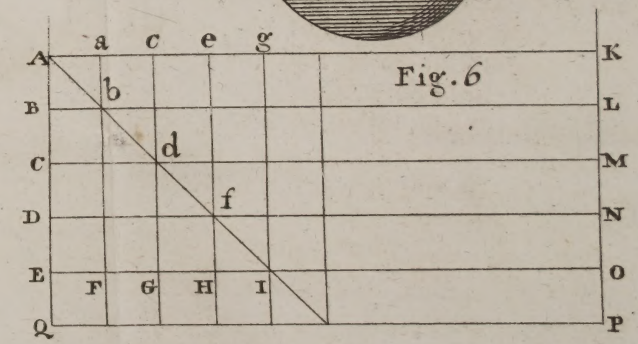
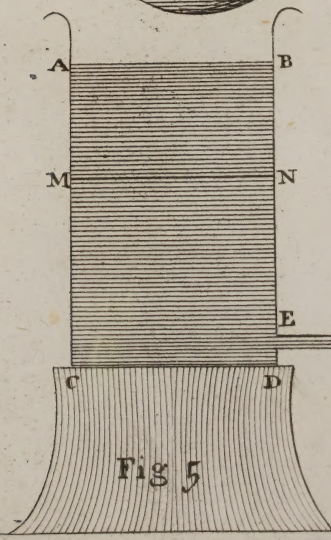
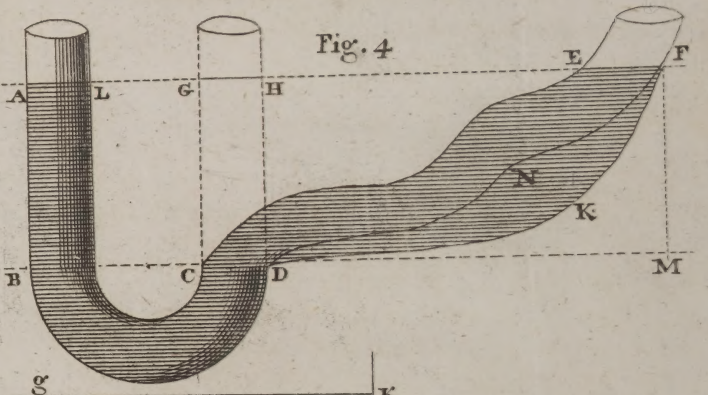
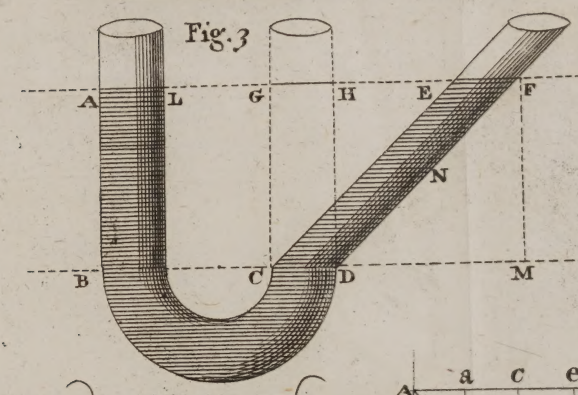
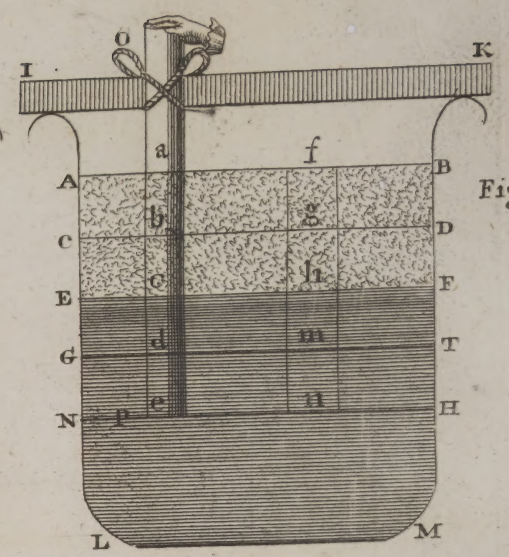
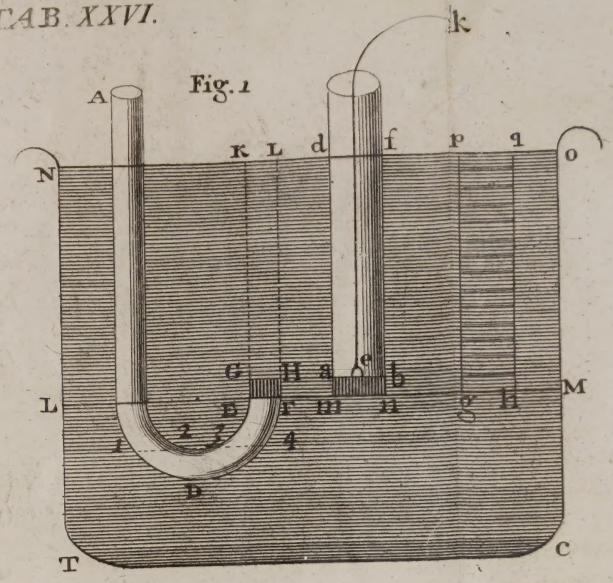
SECT. XLI. The Hydrostatical Law of Lateral Pressures.

XLIV. FROM whence therefore results this Principle concerning the lateral Pressure of Fluids, namely, that the lateral Pressure upon A E being in this Case 10 lb. is the half of 20 lb. or of the Pressure downwards, which the said A E, if it lay horizontally at E I, level with the lowest Point E, would suffer from its incumbent Water A E I g; so that in order to know the Water being at the Height A K, how great is the Pressure which A E bears, we must set off A E horizontally on E I, which bears the Pressure downwards of its incumbing Water A E I g; and draw E I, which will take in the pressing Fluid A E I A, or the half of A E I g.

XLV. It must not be thought, that if the Number of Parts, of which A E or E I are compos'd, were much greater than 5, it would alter the

Proport-

TAB. XXVI.



Proportion ; since, let the Number be never so great, all the Numbers from 0 forwards, being continually multiply'd with the Unit, do always make up the half of their greatest Number, so often taken, as (the 0 or Cypher being reckon'd among them) their Quantity amounts to.

This is plain to Mathematicians, and any Body else may, for his Satisfaction, compute it with a greater Quantity.

SECT. XLII, and XLIII. *Two Experiments about Lateral Pressures.*

XLVI. YOU may find what we have said Num. XLIV, and XLV. demonstrated after another manner by Monsieur Stevin, in his *Hydrostatics* ; but since we, in order to render our Conclusions more certain, are wont to deduce our Proofs from Experiments, we will here add the following Experiment, as we find it standing upon our Notes some Years ago, omitting the whole Calculation for Brevity sake.

We caus'd to be made a Quadrilateral Vessel (*Tab. XXVII. Fig. 2.*) the Height of which M K was about 26 Inches, with a square Hole that could be stopp'd with a Piece of Wood H D R S of the like Dimensions, being of the Breadth of a Foot at R D, and of the same Length at H D ; which Piece of Wood was adapted to the Hole after such a manner with a Leather fix'd to its Edges, as to prevent the Water from oozing out at the Joints.

This Vessel being fill'd with Water up to B D, we knew that there was the Weight of a Foot of Water pressing laterally upon the Piece of Wood H D R S, because the Height of the Water was equal to D R, or to the Height of the uppermost Part of the said Piece of Wood.

Having then examin'd into the Force of this lateral Pressure of the Water by Means of a Balance A E F, the Arms of which A E and E F were Rectangular at E, to which the Weight Y was suspended, we found that this Wood being press'd inwards at E A by Y, could resist a Weight of between 31 and 32 Pounds ; but upon adding more, it immediately burst inwards.

So that the Rule mention'd in Sect. LII. was sufficiently verified hereby, since a Rynland Foot of that Water was about twice as heavy.

It is to be observ'd, that the pressing Part A of the Balance A E F, must be placed exactly upon the Point of the Wood A, where the Center is, or where the lateral Pressure is strongest.

In order to do so, Care was taken that by the Means of the cross Piece of Wood V W, the Axis E of the Balance might be thrust up or down ; and we found that when the Balance press'd higher or lower than A, the flat Piece of Wood (the Water being at highest) yielded to a much smaller Weight or Pressure ; which shew'd that the true Point was at A.

XLVII. We then fill'd the Vessel quite full of Water up to G K, so that the upper Part D R of the wooden Plane D R S H, which bears the lateral Pressure, was not equal to the upper Superficies of the Water, but was below it the Length of K D, or of $\frac{1}{3}$ of a Foot, that is 8 Inches. Wherefore, if what is said before be true, and that H K were $1\frac{2}{3}$ of a Foot, or

20 Inches, we should have seen the lateral Pressure on H D R S, resist a greater Weight.

Having therefore rais'd the Axis a little higher, so that A, the End of the Balance, being hereby apply'd to the Center of the Pressure, was also higher, we found that by putting on the Weight Y of 77 Pounds, the wooden Plane immediately gave way, but that the lateral Pressure held good against 73 or 74 Pounds.

This agreed pretty near with the foregoing Rule, as we found by computing after the following Manner :

Let *Tab. XXVII. Fig. 2.* be transferr'd to *Fig. 3.* and that the Water is from H S to K Z. Then H K equal to $1\frac{1}{2}$ or $\frac{1}{2}$ of a Foot is equal to P H (if we suppose this same H K to be lying horizontally) and H S is a Foot : So that the whole Body of Water of this Breadth, Length and Depth $\frac{1}{2}$ of a Cubical Foot ; and the half of it, which presses laterally upon K H Z S will be $\frac{3}{4}$ of a Foot. If now we subtract from thence the Water's lateral Pressure upon K D R Z, to wit, $\frac{1}{4}$ of a Cubical Foot, it being the Half of $\frac{1}{2}$ a Foot of Water (which last expresses the Magnitude of a Body, the Length whereof R D is 1 Foot, the Breadth *m* D $\frac{1}{2}$, and the Height K D likewise $\frac{1}{2}$ of a Foot) there will remain the lateral Pressure of $\frac{1}{2}$ or $\frac{1}{2}$ of a Foot, or otherwise $1\frac{1}{2}$ of a Cubical Foot of Water, that is, (supposing such a Foot of Water to be 63 Pounds, or somewhat more) of 73 $\frac{1}{2}$ Pounds against H D R S ; which sufficiently agrees with the Rule mention'd *Sett. LII.*

SECT. XLIV. *The Lateral Pressure adapts itself to the Height, and not to the Breadth of Water.*

XLVIII. We likewise observ'd, upon placing a flat Board or Partition (*Tab. XXVII. Fig. 2.*) T a b, after such a manner, that the Water, which before press'd upon D H R S, became divided, or had not above the half a K of its former Breadth K G, that the lateral Pressure was not lessen'd, whilst the Water continued at its first Height K G.

So that from hence also it appear'd, that the Powers of the lateral Pressure remain the same, whether the Breadth of the Water be increas'd or diminish'd ; but that upon augmenting or lessening the Height of Water, those Powers are accordingly augmented or lessen'd.

SECT. XLV. *The Lateral Pressure of Water, with Air pressing upon the same.*

XLIX. But forasmuch as in these Experiments of Lateral Pressures we have supposed Water to be the uppermost Fluid, so that, for Instance, in the Vessel A B C D (*Tab. XXVII. Fig. 4.*) we are to suppose there is no other Fluid Matter above the Superficies of the Water A C, the following Difficulty seem'd to arise, namely, that the lateral Pressure of the said Water A C upon A B would be much greater than it is found to be by these Experiments ; because the Air between A C and ooo, &c. actually pressing upon A B with the Weight of 30 Foot of Water (according to the Barometer) the lateral Pressure against A B would appear to be considerably increas'd.

But

But upon the whole Matter, we shall show by the following Calculation, that the lateral Pressure of Water in the Vessel A B D C upon A B, is not so much increas'd by the Weight of the Air above A C, as that the Force which A B withstands, or which should press inwardly against C D (like the Weight in the foregoing Balance, Fig. 2.) could be sensibly augmented thereby.

Let the Vessel A B D C (Tab. XXVII. Fig. 4.) be fill'd with Water up to A C; above which let us suppose a Column of incumbering Air as high as o o o R o o o; we know that the said Air being also on the other Side of A B, at A, B, i, n, will press likewise against A B laterally from the Side of n i.

Now to find what Pressure A B undergoes by the Water on the Side D C, and by the Air on the Side n i, and how much the first Pressure exceeds the last :

Let us call the Weight of the Air gravitating upon each Point in the Plane n N, to wit, n O, m O, E O, &c. by the Name of a.

Let the Gravitation of the Water K F on the Point F be b, then L G is 2 b, and M H 3 b, &c.

Let the Air-Weight of k f on the Point f be c; then is L g, 2 c, m b, 3 c, &c.

Whereupon (according to the Calculation in Sect. LI. if we do here also suppose five Points of Pressure) the Force of the superior Air, and of the Water in A B C D, which press A B laterally towards n i, will be 5 a with 10 b. And on the contrary, the Force of the upper Air, and of that Air which is at n i B A, which press'd A B laterally back towards D C, will be 5 a with 10 c. So that these two Powers pressing laterally against each other, being drawn by each other, the Force wherewith A B is press'd laterally towards n i, will be 10 b less 10 c.

Now without the superior Air, the lateral Pressure of the Water (according to Sect. LI. and LII.) would be equal to 10 b; and c is equal to about $\frac{1}{1000}$ part of b, if we suppose Water to be 1000 times heavier than Air. So that the surrounding Air does only lessen the lateral Pressure of the Water $\frac{1}{1000}$ part; which in the foregoing Experiment can make no sensible Alteration, and consequently the abovesaid Difficulty is obviated.

SECT. XLVI. *The Augmentation and Diminution of the resisting Force of Fluids produces Motion, and the Force thereof.*

L. HITHERTO we have considered the upward and downward Pressures of Fluids which are quiescent or stagnant, either by reason of Powers really acting upon and against each other, or else by the Resistance and Obstructions of Motion; we should now naturally proceed to inquire into the Powers of those Fluids that are in actual Motion; but forasmuch as this would require a whole Book to account for it, and since what we propos'd to shew here concerning the Law of Altitude or Depth, may likewise be conceived by the Pressure of stagnating Fluids; we will not enlarge this

Digression, which to those who understand Hydrostatics, may seem already much too long.

We shall only observe further concerning the Powers pressing upon each other, that if in *Tab. XXVII. Fig. 5.* The Tube *bkg* is equally fill'd with Water up to *a* and *f*, since *d* is press'd upwards by *ab*, and downwards by *fd*, the Part *d* will quiesce or stand still, if the Powers *ab* and *df* are equal; but if one of 'em be lessen'd to *ed*, or the other increas'd to *hb*, *d* will be removed towards that Side where the Force is smallest, or in this case to *g*; and even with as much Force, as the Difference of both Powers is, that act on each Side upon *d*. This may be easily try'd, and wants no further Proof.

SECT. XLVII. *Fluids are moved by, or rather after taking away a Resistance, and the Force thereof.*

LI. MOTION may likewise be produced, by removing a Resistance which obstructed Motion. For Instance, blow into a Tube at *g*, which is fill'd in both its Legs with Water up to *a* and *f*, till the Water subsides from *f* to *e*, and rises from *a* to *b* on the other Side; then presently stop the Orifice *g* with your Finger; whereupon all will stand still, and your Finger will become the Impediment or Resistance of Motion. This appears by removing your Finger, upon which the Motion will ensue.

Now by what has been said, it is obvious that whilst the Finger continues upon *g*, and the Fluid is stagnant, the Part *d* is press'd upwards by *hb*, and downwards by *dg*; and that the resisting Power or Finger is press'd upwards by the difference of the Powers *hb* and *dg*. So that this Resistance or Finger being taken away, a Motion will be made towards the Side of the Resistance; and even with that Force with which the Resistance was press'd when the Fluids were quiescent, unless upon removing the Resistance, no other actual Force begins to operate.

SECT. XLVIII. *Transition to Hydraulics, or some few Hydrostatical Examples.*

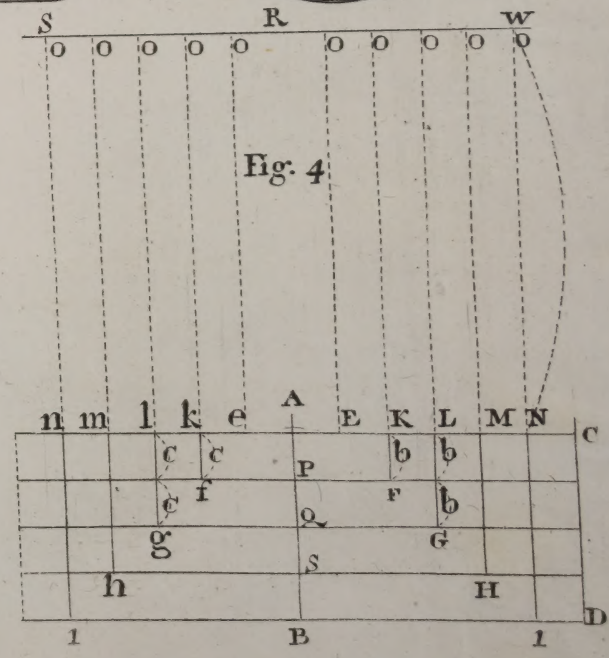
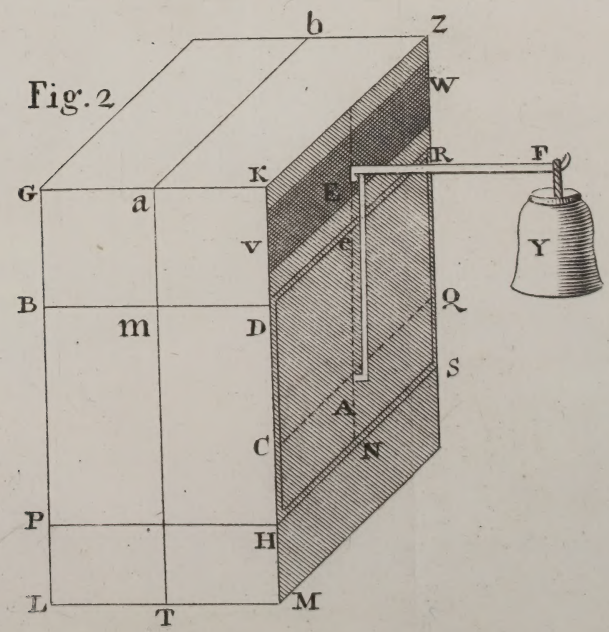
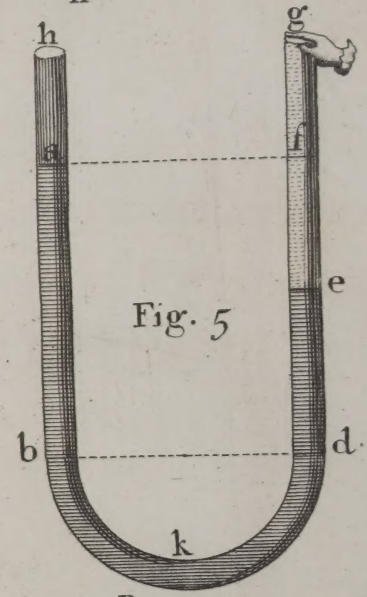
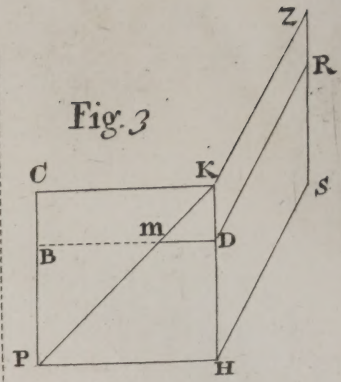
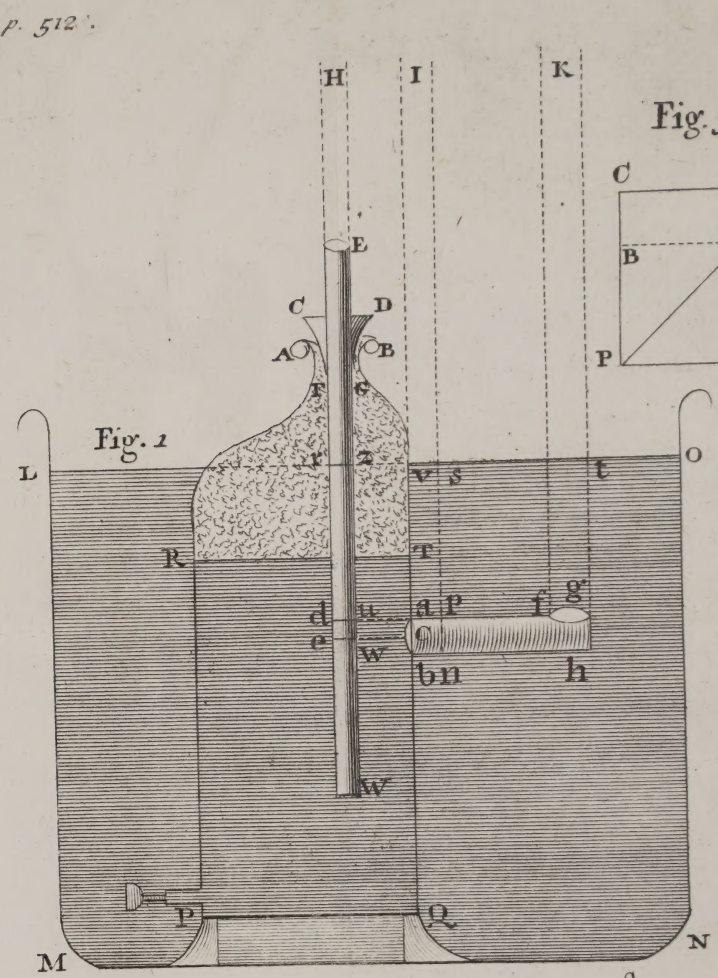
NOW that Fluids do so exactly observe these Laws; that, *First*, every thing which is deduced from thence by good and just Consequences (all Circumstances being rightly observ'd) is likewise experimentally verifi'd in the same: And, *Secondly*, that these Fluids, before they recede from *this Law of Altitude or Depth*, do moreover produce Effects, which, to such as are unexperienced in Hydrostatics, appear to be so many Wonders, and of whose manner of operating, even the greatest Mathematicians acknowledge themselves ignorant, or at least uncertain, we will prove by some few Instances.

SECT. XLIX. *Calculation of the Force of a Syphon.*

LII. THE First Instance, that we may begin with one that is simple, shall be the Operation of a Syphon.

ABCD is a Vessel fill'd to the Brim with Water (*Tab. XXVIII. Fig. 1.*) in it there is placed a Curve Tube or Syphon EGHK, likewise full of Water, the Orifice whereof IK is for that purpose stop't with the Finger or otherwise.

fronting p. 512.



If now you remove your Finger from I K, every Body knows experimentally, that the Water will run out from I K to Z, rising up in the mean while in that Part of the Syphon E G, which is shortest, and coming down in the longest H K, as long as the Water in the Vessel continues higher than the Mouth of the shortest Leg E F.

Now to know from the foregoing Principles, the Force and Manner where-by, and whereon this Operation of the Syphon is brought about:

Stop the Syphon again with your Finger at I K, by which means the Water in that, and in the Vessel will stagnate.

Suppose then W X to be the upper Place of the Air which presses here upon the Water, and produce the Horizontal Plane of the Water A D, thro' P Q to R S, whereof L M, N O, P Q and R S are equal Parts; thereupon, according to the preceding Rules, the Part L M will be press'd with the Weight of the Column of Air incumbering on it.

Let us for Brevity sake call the Pressure of Weight thereof upon L M, *a*, or if you please 100 Pounds more or less; especially if People be not used to this way of Letters.

Accordingly we will express the Weight of the Water-Column P Q I K by *b* or 10 Pounds, and that of the Air R S T V, being of the same Height, by *c* or 1 Pound.

Now since L M, N O, P Q, which are all equal Parts of the same Horizontal Plane A Q, and all Water, and to all which we may suppose, that a Line or Thread may be drawn, without passing thro' a solid Body, or any other Fluid besides Water.

And since by the Action of the Syphon the Plane L M moves, or is press'd downwards, that of N O upwards, and that of P Q again downwards, if every Thing be reduced to Rest by stoping the Orifice I K, the Powers whereby the said Planes were press'd up and downwards will be equal, according to *Seet. XLI, &c.* and L M being press'd downwards by the Weight of the Air-Column L W M, that is, by *a*, or by 100 Pounds, N O will be press'd upwards, and P Q downwards by the same.

If now we join to the Weight of this Air-Column of *a* or 100 Pounds, which Presses P Q downwards, the Water-Column P Q I K of *b* or 10 Pounds, by which I K is likewise press'd downwards; the Force or Weight that presses I K will consist of *a* join'd to *b*, or of 100 and 10 Pounds, to wit, of the Air and Water-Columns together. And so it is with this Force, that the Water gravitates downwards to Z.

If now the Horizontal Plane passing thro' I K be extended to V, and T V suppos'd equal to I K, then will T V be press'd downwards by the whole Air-Column T V X, that is by R S X of *a*, or 100 Pounds (the same being equal to L M W) and by R S T V of *c* or 1 Pound; that is, of *a* and *c*, or 100 and 1 Pounds together.

Now with just so much Force (according to *Seet. XLIII.*) is the Part I K, or rather the Air pressing against I K, or the Finger (if we do not consider the Thickness thereof) press'd upwards.

So that we see here two Powers pressing against each other on I K, or the Separation of the Water and Air, operating and acting against one another.

Of which, that that presses I K downwards, has been found already to consist of a added to b , or 100 and 10 Pounds. And that which presses I K upwards, to be no more than of a and c , or 100 and 1 Pounds; so that this last, a and c , or 101 Pounds, (*i. e.* the smallest Sum) being subtracted from a and b , or 110 Pounds, the Remainder is b less c , or 10 less 1, that is 9 Pounds.

And this shows the Force wherewith I K is press'd downwards more than upwards, and it is equal to the Weight by which the Water-Column R Q K I, b or 10, exceeds the Air-Column P S T V, c or 1.

So that if you remove your Finger from I K, and suffer these two reciprocally gravitating Powers to act against each other, it is plain that the Water at the Orifice of the Tube I K, is by the lately mention'd difference of Weight between the two Columns P Q K I and R S T V, that is b less c , or 9 Pound Weight (supposing all the Numbers to be as above) press'd or protruded downwards to Z.

Thus we see the Force wherewith a Syphon flows, deduced from the aforesaid Principles, and the Fact is obvious to every one.

But we must beg our Readers to take notice here, as well as to remember hereafter, that we do by no means pretend that these Numbers of 100, 1, 10, &c. are the just Proportions of the Weight of Water and Air; but that we only mean thereby to show that a Column of Water is much heavier than a like Column of Air, and to consult the Ease of those who are not accusom'd to Letters in Calculations.

SECT. LI. *Of a Fountain that Spouts or Springs higher than the Water that supplies it.*

LIII. LET us now propose an Instance that is a little more compounded than the former.

How to make a Fountain whose Stream rises much higher than the Water above in the Cistern, which causes it to spring out without the Application of any Force-Pumps, Bellows, or other Instruments, and without any other Means whatever, saving the Gravity or Weight of the Water itself.

This may be done after the following manner:

A B C D (*Tab. XXVIII. Fig. 2.*) is an open Cistern, from which an open Tube N R is carried downwards thro' the Covering E H of another Cistern E F G H, shut so close that no Air can get in, passes down to R, almost to the Bottom of the Cistern F G.

From the upper Part of this lowest Cistern E H, there rises a second Tube S T, passing on almost as high as T D, or the Lid of a second Cistern D C K I, which is likewise closed; and from thence there is again derived a third Tube to L M Q, which is stop't with a Cock that has a large Orifice at M O.

Moreover, in the Cistern D C K I, there is a Hole at P, which can be open'd and shut by another Cock or Stopper.

To set this Machine to Work :

Pour in Water at the Orifice P into the Cistern DCKI, till the Tube L Z Q O be full, shut the Cock M O, continuing to pour in Water at P, till the Water rises in the said Cistern to the Height T Y, or level with the Mouth of the Tube T.

Then shut the Cock P, and pour Water into the Cistern A B C D till it rises to the Height 2 T. This is not indeed absolutely necessary here, but is prescrib'd, to the end, that by taking the same Height of Water in both the upper Cisterns, the Calculation may be the more simple, and consequently more intelligible to unexperienced Persons.

This being done, and every Thing at Rest, upon opening the Cock M O, you will see the Stream of Water rising up to V, thro' the middle Orifice of the flat Plate 5 6, or at least to a very considerable Height above the uppermost Superficies 2 T of the Water which is in the Cisterns A B C D and D C K I, and which presses up the Stream 6 V.

It must be here observ'd, that forasmuch as the Water of the upper Cistern A B C D descends into the lower E F G H during the Play of the Fountain, there must be a Hole in the latter from whence the Water may be discharged ; which being done, it must be stopt again, if you would play the Fountain again.

Or otherwise (which I find most convenient in mine) you may place a little Pump at 2 thro' the Tube N R, down to the Bottom F G, and then pump the Water out of the lower Cistern E F G H thro' N, the Cock being open'd in the Cistern D C K I.

To know then with what Force the Stream rises from the Cock N O, or the Orifice 5 6 :

Let the said Cock be turn'd or shut again, whereupon the upper Cisterns and Tubes being fill'd with Water, all will be still ; and let it be suppos'd (that we may not repeat the same) that all the Tubes as well the real ones N R, T S, L Z, as the imaginary ones W 2, X 4, and 4 5, are of the same Width. Tho' this likewise is only requir'd for Calculation sake, since we may otherwise use for this Purpose, such a Part only of a larger Tube as is equal to the Width of a smaller.

Let then W X be the uppermost Plane of the external Air ; and let that of the Water T Y be continued to 4. Consequently, as we have shewn before, the Part 2 of the Superficies of the Water in the upper Cistern A B C D, will be press'd downwards by the Column of Air W 2.

Let us again call the Weight of the said Column *a*, or 1000 Pounds.

After the same manner we will term the Weight of the Water-Column R 2, *b*, or 100 Pounds ; as also that of the Air-Column T 3, *c* or 10 Pounds too : The second Water-Column Y Z shall be express'd by *d*, or 80 Pounds, and the second Air-Column 4 M by *e*, or 8 Pounds.

To proceed then :

The Part R of the Horizontal Plane R 3 is press'd downwards under the Tube N R by the Weight of the Air-Column W 2, or *a*, otherwise 1000

A a a a

Pounds

Pounds jointly with that of the Water-Column $2R$, or otherwise b , or 100 Pounds; and consequently by a and b together, or by 1100 Pounds.

But all Things being quiescent, we know, according to the foregoing *Set.* XLIII. that with the same Force as R is press'd downwards, the equal Part 3 is press'd upwards; so that the Force which drives the Part 3 upwards, is likewise equal to a added to b , or 1100 Pounds together.

Now the Air-Column T_3 , nam'd c , and suppos'd to be 10 Pounds, does also gravitate with the same Force upon 3 downwards. Wherefore Subtracting this downward-pressing Weight c , or 10 Pounds, from the Force that presses 3 upwards, or from a and b , that is 1100 Pounds, the Force with which the whole Air-Column T_3 , and consequently also its Superficies T , by the Difference of both these acting Powers is moved upwards, does result from thence. And the same must be express'd by a and b together, less c ; or by 1100 less 10, that is by 1090 Pounds.

Again, since T is a Part of the Air's lowermost Horizontal Plane TY , which Air presses upon the Water in this Cistern $DCKI$, and since Y is an equal Part of the said lowermost Horizontal Plane, it follows according to the above-mention'd Laws of Hydrostatics, that Y is press'd with as much Force downwards as T upwards; so that Y is press'd downwards with a Force equal to the said a and b together, less c , or with 1090 Pounds.

To which if we here add the Weight of the second Water-Column YZ , that is, of d , or 80 Pounds, the Part Z_9 will be press'd more strongly downwards with this Weight than the Part Y ; and consequently the Weight which presses Z_9 downwards, will be equal to a , b , and d together less c , or 1000, 100, and 80 together, less 10; that is, 1170 Pounds.

And since Z_9 and MO are equal Parts of the Horizontal Plane ZO , MO , press'd with the same Force upwards:

If now the Cock at MO had no considerable Thickness, and yet hinder'd the Water from springing out, it would appear that MO were press'd downwards with the Force of the whole Air-Column MX , that is of X_4 , a , or 1000 Pounds (for this is equal to W_2) and $4M$, e or 8 Pounds, that is, taking in all together, MO is press'd downwards by a and e together, or 1008 Pounds.

And it has been shewn before, that it is press'd upwards by a , b , and d together less c , or by 1170 Pounds.

Wherefore, if we suffer these up and downward pressing Powers to operate on each other, as they do, when the Cock is open'd at MO ; it is plain that the Water which presses upwards at MO being strongest, will over-balance the opposite Power that presses the said MO downwards, and be driven upwards by the difference of the Powers acting against each other.

This Difference is found by Subtracting the smallest downwards pressing Force a and e together, or 1008 Pounds, from the greatest a , b , and d , together less c , or 1170 Pounds,

So that the Difference, or the Force, wherewith the Water ascends at M O, is equal to b and d , less c and less e , or to 162 Pounds.

Or to express the same by Words that may be apply'd to the Fountain, and to take these Things for the Letters which they denote: The Water will be protruded out of the Cock M O, with a Force equal to the Weight of both the Water-Columns 2 R and Y Z, Subtracting the Gravity of the two Air-Columns T 3 and 4 M.

Now since the Weight of the Air with respect to that of Water, is as $\frac{x}{10000}$, it may be omitted in this Calculation, as making no considerable Alteration therein. And we may advance, without committing any Mistake worth Notice, that this Fountain spouts with as much Force, as if the gravitating Water in the Cistern had the Height of both the Water-Columns 2 R and Y Z, that is, of b and d placed one upon the other.

So that from hence it is easie to infer, why the Stream M V Springs much higher than the highest Water A 2 in the Cistern, since the Height thereof alone is equal to that of a Water-Column 2 R in this Contrivance of a Fountain. And that Experience agrees with these Propositions, every Body that pleases to try, will find as well as we.

SECT. LII. Of a Fountain of Hero, the Stream whereof is longer than the Fountain high.

LIV. SOME Years ago, I caus'd to be made another kind of a Table-Fountain, of the Nature of that of *Hero Alexandrinus*; but with this Difference, that whereas in that of *Hero* it is not possible to make the Stream that spouts out to attain to the Height equal to that of the Fall of the Water, or of the Fountain itself; yet in mine, notwithstanding the Height of the Machine, was no more than $3\frac{1}{2}$ Foot, the Jet rose strongly five Foot higher than the Water in the upper Cistern.

The Structure is thus: G A F H (*Tab. XXVIII. Fig. 3*) is the uppermost Cistern, being open, and having under it two smaller, and every where Air-tight Cisterns A B C D, and D C E F; each of these has an Orifice or Hole, one at M, t'other at N, and both of 'em may be render'd also Air-tight, by stopping them with a Cork covered with a wet Bladder, or a Cock. There are likewise two close Cisterns below, S T R P and P R Q O. From the Bottom A F of the uppermost Cistern G A F H, there passes a Tube K I downwards almost to the Bottom R T of the Cistern P R S T; but in such a manner that the same, or whatever it contains, has no Communication with the Cistern D C E F, through which it passes. And from 3 in P S, there is carried a Tube 3 L upwards, just below the uppermost Plane D F of the Cistern D C E F; from the Bottom of which C E, there descends again at 9 a Tube at 9 b, terminating in the other Cistern Q O P R very near the Bottom of it Q R. And this same Cistern Q O P R sends again a Tube 4 Z upwards, which beginning at 4 is carried on to Z exactly, under the uppermost Plane A D of the Cistern A B C D. Lastly, At A D there is a Tube p r close solder'd at 5 6, which rises to r b only, or a, very

very little higher than the Plane A D ; and passes downwards to P, or nearer to the Bottom B C.

On the Top of this last Tube, we fix'd another r 8, which at W 8 was covered with a flat Plate, having a small round Hole in the Middle of it, thro' which the Stream was to pass, and we clos'd it at the Joint r with *Emplastr. de Minio*, so that it was impervious either to Water or Air.

Now to set this Machine to Work :

We inverted or turn'd it upside down, so that the Cistern G A F H was undermost, and having fill'd both the Cisterns A B C D and D C E F, with Water at the Orifices M and N, we stop't the said Orifices very close with a Cork and Bladder, putting a Finger in the mean time upon the Hole in the little Plate W 8, to the end that the Water pour'd in at M, or so much of it as was above p , might not run out.

Then suddenly placing the whole Machine in its former State, so as that the Cistern G A F H was again uppermost ; we pour'd without delay some Water that was at hand in the said Cistern ; whereupon, presently afterwards, we saw a Stream 8 7 rising out of the Tube r 8 thro' the little Hole, which Stream, when measur'd, was much longer than the Height of the whole Machine, as has been already said.

It will not be necessary to give an Account here, how the Water subsiding, or sinking from G A F H through the Tube K I presses the Air out of the Cistern P R S T through the Tube 3 L upwards, which finding no room any where but by pressing downwards the Water in the Cistern D C E F, and and in the Tube Y h , protrudes the said Water towards the Cistern O Q R P with a much greater Force than that of its own or single Gravity. At which Place the Water likewise ascending, the Air is protruded with the same Force from O Q R P thro' 4 Z to the Cistern A B C D, which (without counting the Air in the Tubes L g and Z v , because of its Levity and small Resistance) causes the Water to spring out of the Tube p 8 ; after this manner with almost the Force of both the Weights of the Water-Columns Y h and K I. In the same manner we may deduce the Operations of the foregoing Fountains, Syphons, and others, whereby, without a Calculation, we may also form a general Idea of their Properties. I thought it sufficient to give my Readers one only Instance here, it not being my Design to write an entire System of Hydrostatics. They who would impute the Force wherewith the Water issues out of the Fountain exactly, may do it after the Method of the aforementioned Examples.

But before I proceed any further, I must add, that this Machine may be form'd after a much more convenient manner, so as that one need not invert, nor yet stop the little Hole of the Column W 8 with the Finger, or any thing else ; this may be done by Stop-Cocks in other Places, and by making the Orifices M N above at A F, as is known to every Body that has any Skill in these and other kinds of Water-Works. Yet I have rather chose to express it in the present manner, because it is that in which I made the Experiment, and in a Place where we could form this whole Structure of no other Metal than Tin, nor could have the Assistance of such Workmen as

are necessary in such Matters. Whereas the other Fountain was prepar'd by a Person of good Judgment, and who was well instructed concerning the Frame and Make thereof.

Nor will it be difficult to one that rightly understands this, and the foregoing Disposition of a Fountain, to cause a Stream of Water to rise up to a given Height by a requisite Multiplication of Cisterns and Tubes, the Height of the Descent of Water being likewise given. It is certain at least, that all this may be deduced by Argumentation, and confirmed by Experience.

SECT. LIII. *The Motion of Water in a Curve Tube.*

LV. IN the last Place we shall add something, which, tho' of little Importance, yet at first Sight has appear'd wonderful even to some Mathematicians themselves, to whom we have several times communicated it; and which serves to confirm the foregoing Laws after a strong manner.

$YmnZ$ is a Cistern or broad Vessel (*Tab. XXVIII. Fig. 4.*) fill'd with Water up to the Brim; $PONM$ is a Cylindrical Glass, with the Bottom PO upwards, and the Mouth MN just under the Surface of the Water in the Cistern, and containing before it was inverted, some Water in it, which (the Mouth of the Glass being thus turn'd downwards,) continued suspended therein at the Height QR .

Moreover, LBV is a Curve Tube, both Legs of which being fill'd with Water to the same Height L and r , I put my Mouth to the Orifice V , and blow'd it back from r to A , thereby causing it to run out at L .

The Water by this means being contain'd between L and A , to prevent its subsiding at L , and rising at A ; I presently stop't the Orifice V with my Finger, whereby the Water remain'd so much lower at A than at L .

Then I put the said Tube $LB A$ under the Glass $MNOP$, so that a Column TL of Water, (and the Glass being not quite full) a Column also of Air Tz was above the Orifice L .

Thus the Water being at unequal Heights in the Tube, under the Glass, and in the Cistern; (soasmuch as that in the Leg of the Tube LB , was not only the entire Length SL or Ar higher than in the other Arm bV ; and besides the Water-Column TL press'd yet more upon the Orifice L , without counting all the Air Tz .) who could at first Sight, unless he were well vers'd in *Hydrostatics*, imagine otherwise, than that by the greater Height of Water, at SL , or rather at ST , the water would be forced upwards at A , when the Finger was remov'd from V .

And yet we find by Experience, that instead of A rising to r , the Water will subside from A to F , as soon as ever the Finger is taken from V .

To discover therefore the Reason of this Phenomenon, so surprizing to some People, nothing more is necessary than to trace the same back to the before-establish'd *Laws of Fluids*, when you have again blown the Water down to A , and stopp'd the Orifice V , and reduced all to its former State.

Let us then again suppose WX to be the upper Superficies, and AE an Horizontal Line drawn parallel to YZ . Now let the Air-Column WE equal

equal to X A (the Finger being remov'd from V) be each call'd a , and the little Water-Column A F be call'd b ; and the little Air-Column G E of the same Height with A F , be c ; each of the Water-Columns H g and D T be d ; and the little equal Air-Columns g and u T be e : Whereby, according to the foregoing Method, the Force may be computed with which the little Water-Column A F is press'd down to F , or to the Depth Y Z .

But this may be likewise more briefly done after the following manner: The Part G is press'd by the Air-Columns W E and E G , or by a and c ; but (according to *Sett.* XLIII.) the Part Flying in the same Horizontal Plane Y Z , is press'd upwards with the same Force a and c , when upon stopping the Orifice V with the Finger, all is still; forasmuch as there can be drawn a Thread from G to F , without passing thro' any other Solid or Fluid Matter: But if now you remove the Finger from V , the Part will be press'd down by the Air-Column X A a , and the little Water-Column A F b ; so that the Force which presses F upwards, is a added to c , that which presses the same downwards is a added to b .

Now since b is Water, and c Air, the downward pressing Force upon F , or a added to b , is greater than the Force pressing upward express'd by a and c ; and consequently the Part F is press'd downwards by the Difference of this Force, or by the Force of Gravity wherewith the little Water-Column extends the equal Air-Column E G , that is by b less c .

From whence it appears, that whilst A F or b is Water, and heavier than G E or c , which is Air, the Part F , and consequently the Column A F , will be press'd or move downwards, and never cease till A subsides to F , and the Column A F becomes Air likewise.

And then the Difference of A F and G E , or b less c will be nothing, and the Force pressing up and downwards upon F , equal; for which Reason the Water in the Tube V b will not be higher than at F , or equal to Y Z , when all is quiescent by its Weight only. And the same is conformable to Experience.

We might here subjoin the Demonstration, that if L , the Orifice of the Tube L B V , stood out at any Height above the Water Q R in the Air P Q O R , the Water would not subside so low as F or Y Z , but that it would remain and rest proportionably as much higher above F or Y Z , as L should be above Q R .

I cannot forbear shewing here, how necessary the last Observation made (*Sett.* XLIII) is in this Calculation; to wit, that since the Orifice L , of the Tube L B V , being under the Water at Q R , a Thread can be drawn from G to F , that passes thro' no other fluid Matter than this Water; we may presently discover after a much shorter manner the Pressure upwards of F , by the Pressure downwards of G .

But when the Mouth L of the Tube L B V happens to be above the Water Q R , in the Air P Q O R , we shall find that the Thread which we would have drawn from G to F , must first pass thro' the Air P Q R O out of the Water to the Orifice L , before it reaches F ; for which Reason the aforesaid

short

short or abridg'd Computation can't be made true, since, for this Reason, F and G will not be press'd with equal Force upwards and downwards, the Finger being upon V, tho' they be equal Parts of the same Horizontal Plane. This will appear clearly to every one that shall compute it after the manner of those Examples mention'd, *Sett.* LX, and LXI.

But this may suffice to give a short experimental Example of these *Laws of Hydrostatics*.

This Experiment may be made with little Trouble or Charge, if you put a Curve Glas Tube in an Ounce Viol almost full of Water, adapted to the Mouth of the Viol, that no Water can run out of it when inverted or turn'd upside down.

SECT. LIV, LV, LVI. *An Hydrostatical Paradox shewn by two Experiments.*

LVI. Now that these many thousand Parts of which Fluids consist, how ignorant soever of what they are doing, observe so accurately these *Laws of Height*, that before they depart from them, they produce Effects incredible to many Persons, will appear from what follows.

Let (*Tab.* XXVIII. *Fig.* 5.) DC be a round streight Tube, of as great a Length and Breadth as you please, in which two other Tubes AC and BC do open, or even as many more Tubes as the Circumference of the first Tube DC will contain, and these also may be as large as you will; but for the sake of Plainness, we will suppose there to be no more than three, and of equal Bigness.

Then fill all these Tubes with Water to an equal Height, which, upon opening the Cocks G, E, F, will press upon the Base C of a Vessel of Communication CTH, fitted to the Cocks and Tubes; and upon removing that Base or Bottom, would run out thro' C.

Now according to the foregoing *Laws*, it is obvious to all that understand *Hydrostatics*, that if all the Cocks, G, E, F, be shut, and upon opening any one of them, the Water contain'd in each of these Tubes severally, will press on the Bottom C with the same Weight; and that therefore if the Water in DC only (supposing the Cock open, and G and F shut) presses on the Bottom C with the Weight of 100 Pounds, the Water in the Tube AC only (the Cock G being open, and E F shut) will press the Bottom C with the same Weight of 100 Pounds; and so likewise will the Water in the Tube BC.

Now since the Water in each of these Tubes does alone, and without the Weight of the other two, press upon the Base C with 100 Pounds; let one who has never seen these *Hydrostatical Experiments*, nor heard of 'em, ask himself with what, or how much Weight all the Water in the three Tubes acting jointly, and the three Cocks being open, will press upon the Base C; and let him tell us, whether he does not find himself at first dispos'd to answer (as I have known many learned and ingenious Men do) that since the Water in each single Tube presses upon C with 100 Pounds, all three of 'em operating together, will press with thrice the Weight, excepting the little Water at THFE G, which lies between the Cocks and the Bottom C, and

and always remains the same; which however, if the Tubes be taken long enough, makes no remarkable Difference.

But in case we should tell him; *First*, That far from answering rightly, he has quite mistaken the Matter; and that altho' the Water in each of these Tubes does singly press upon the Bottom C with the full Weight of 100 Pounds; yet when all three of 'em act upon the said C together, the Pressure is no more than of 100 Pounds, even though the Tubes were larger, and more numerous, and consequently contain'd in them a greater Weight of Water; for Instance, if each Tube like NBF were of the Size and Figure of NFR, or any other; provided only that the Water in each of the Tubes should continue at the same Perpendicular Height DH, or RS, and the Base, which bears the Pressure, of the same Extent.

And, *Secondly*, that the same happen'd by virtue of the aforementioned Hydrostatical Law, that no Part, as TH, of an Horizontal Plane TS, does ever bear a greater Burden than the Weight of the Column of Altitude, which has TH for its Basis, and DH or RS for its perpendicular Height: He will see indeed that this is a just Consequence of this Law; but undoubtedly also confess, that the manner after which the Water must be dispos'd in these three or more Tubes, so as not to gravitate more with a triple or greater Quantity of Water, than with one third thereof, unknown to him.

The rather, since he sees that such Pressure is perform'd not by a Fluid actually put in Motion, but by a quiescent one.

LVII. And to the end, that they who read this, should not doubt of the Truth of the Experiment, which, unless they were thoroughly vers'd in *Hydrostatics*, they could hardly avoid, let them please to compare the following Experiments therewith, which are only made to support the Truth of the former against those who question it. I find them thus describ'd among the Experiments which I noted some Years since on my Journal.

I caus'd a Machine to be made after the following manner: MNQR (*Tab. XXVIII. Fig. 6.*) is a Tin Tube having a Cock at K, which can stop and open the Communication between the upper and lower Part of the Tube. From this Tube at S, there rises another oblique one TS, growing wider and wider to the Top OTP, after the manner of a Funnel, having likewise a Cock at L, which can open and shut a Passage between the Fluid that is above and that below it; at the end of this Tin Tube at QR, there is another Glass one QRGH stuck into the former, and both cemented with *Empl. Diachylon*.

Then I took a large Cylindrical Glass AEFB, and fill'd it up to CD with a strong Pickle, and binding the Tin Tube together with the Glass one, fast to a transversal Piece of Wood XV; being empty, I let them down into the Pickle to a certain Depth.

Whereupon pouring gently some Oil of *Turpentine* into the Funnel and Tube (both Cocks being open) after that a part of ran it out at GH, and produced a Cream of floating Oil upon the Pickle at ABCD, we found that the said Oil being lighter, and consequently kept up by the Weight of the Pickle, at MNOP, for Instance, or at least much above the Superficies of the Pickle, remain'd in that Condition in the said Funnel and Tube.

Having

Having then stay'd till all was perfectly still, we observ'd a Drop of Oil hanging below at the Bottom of the Glass Tube G H, which immediately, upon pouring some little Quantity of Oil into the Funnel at O, or the Tube at N, by such a small Accession of Pressure fell off from G H, and emerged in the Pickle. After which (the Piece of Wood V X being ty'd very close to the Glass Vessel, that it might not stir) when another Drop of Oil was hanging at G H, we softly turn'd both the Cocks at K and L, and made them fast; and then found that whether one or both of 'em were open'd, the Pressure was not so much alter'd, as to cause this suspended Drop of Oil to fall off, tho' we had seen before, that it always so happened by the Addition of a small Weight, which was not to be compar'd to that of the Oil in the Funnel.

From whence (not to recapitulate all the Consequences deducible from the many *Hydrostatical* Laws which we have before laid down and proved) it appear'd, that the Pressure of the Oil in the Tube N H, was neither increas'd nor diminish'd; whether it was that the Pressure of all the Oil which was in the Funnel S P O, acted and pressed downwards, or whether it was hinder'd from doing so by the Cock L.

LVIII. For the same Purpose we join'd a Curve Tin Tube D E F, *Fig. 7.* to the preceeding Instrument B C D, and sticking into it a Glass Tube F A, clos'd 'em together as before at D and F. Then the Cocks being open, we pour'd common Water into the Funnel C, till it rose to the same Height A B C in the said Funnel, and both the Tubes A and B: And moreover, having opened and shut each of the Cocks K and L, and afterwards both together, we could not observe the least sinking or rising at A; so that it also appear'd from hence, that the Pressure of the Water in the Tube B D, whereby the Water in E F was sustain'd at the Height A, and did neither increase nor diminish, but continued entirely unalterable, whether the Water in the Funnel gravitated on it downwards or not.

From both which Experiments, what is said above in *Seç. XLIV.* seems to be sufficiently confirm'd, as strange as it may otherwise appear to any one at the first Sight, altho' it be obvious enough to such as understand *Hydrostatics*.

SECT. LVII. and LVIII. *Another Hydrostatical Paradox confirm'd also by an Experiment.*

LIX. ANOTHER Instance concerning which, even the greatest Mathematicians freely own their Ignorance (or at least their Uncertainty) as far as relates to the Manner of the Water's working; we will here offer, not according to the little Measure or the Instruments wherewith we perform'd it, but as in the former, so as to render it more intelligible, and to make a greater Impression.

Let A B L M (*Tab. XXIX. Fig. 1.*) be a Vessel represented here in its Profile or Section; and for the sake of Perspicuity, suppos'd exactly square, and the Dimensions of its Length and Breadth to be 12 Foot: This Vessel must likewise be supposed to be shut close with a flat Horizontal Covering

B b b b

A B,

A B, of the same Breadth, having at V R a lesser square Orifice, in Length and Breadth 2 Inches, or $\frac{1}{6}$ of a Foot, from whence there rises a square perpendicular Tube R Q S V, of the same Bore as the little Hole V R, but its Height Q R of 36 Foot; let the Height of the Vessel W A be eight Inches or $\frac{2}{3}$ of a Foot.

Below, at W Z, the Cistern A B W Z is quite open, but there is a loose wooden Bottom Frame lying upon the Brim of the Cistern M N, L O, tolerably strong and inflexible, and so placed, that when the Water is at any Height, nothing can pass between the Frame and the said Bottom. We had put under a much smaller Bottom, which we had used for this Purpose, a thick wet Piece of Leather, which lay upon the Points of the upwards bent Tin Brim O and N, and was kept there by the Gravitation of the Water upon the wooden Brim being press'd downwards, kept the Water intirely in the Cistern.

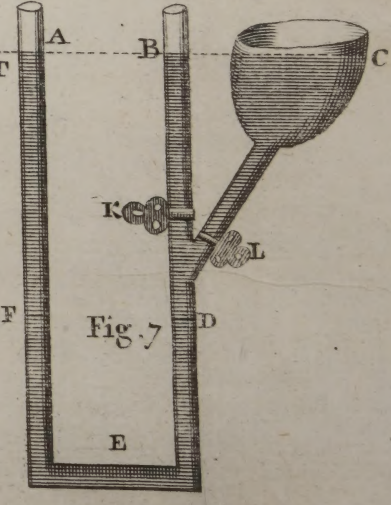
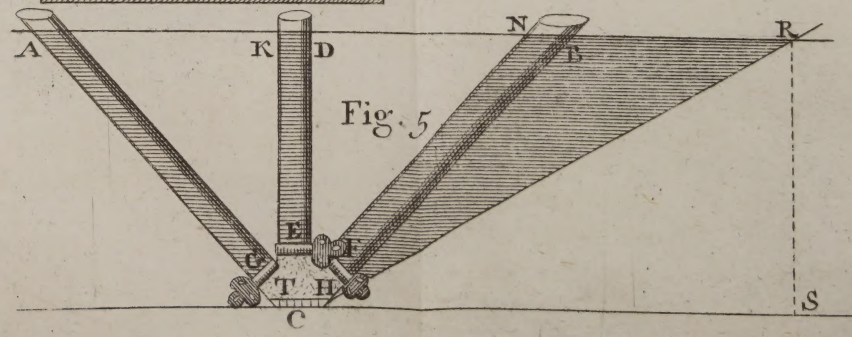
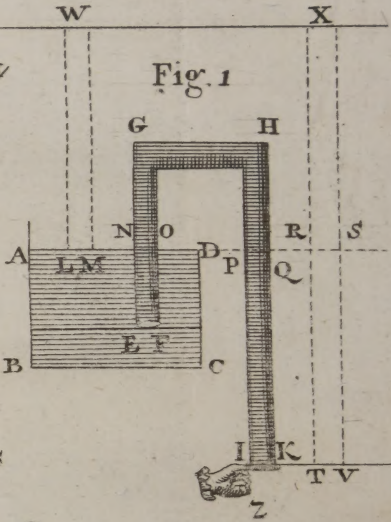
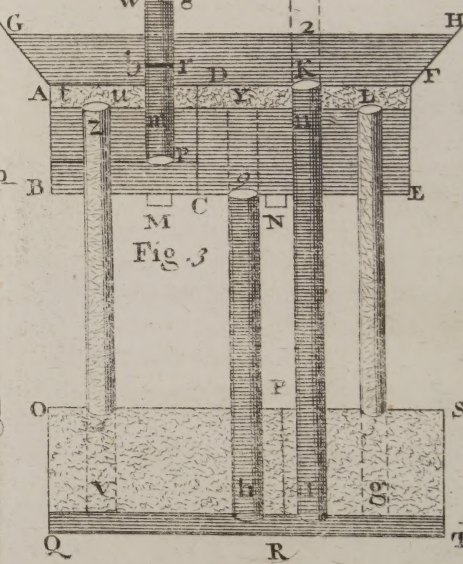
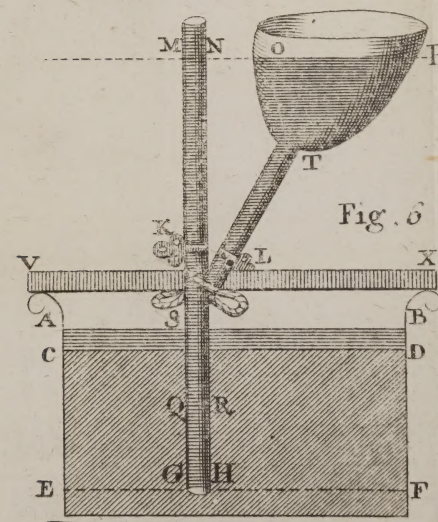
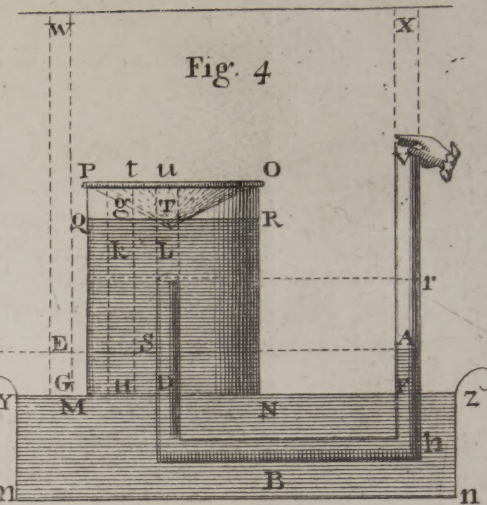
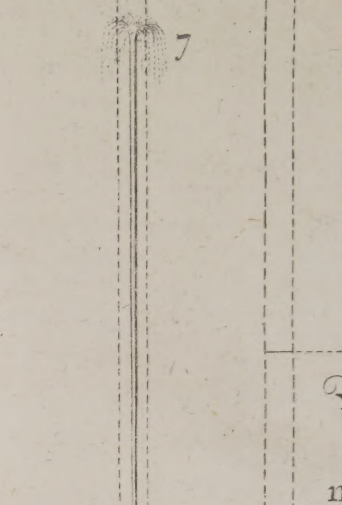
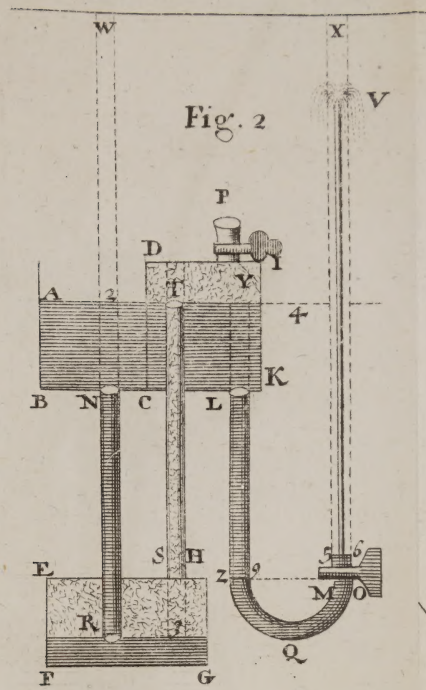
There was besides, a Ring fasten'd at E in this Bottom, from which a String passing thro' the square Tube, was ty'd above at F, to one end of the Balance H G F; so that by drawing the said String F E upwards, the said Bottom W Z could be rais'd up at the same time.

Then pouring Water into the Cistern A B Z W, up to the Brim A B, it is plain that the Length and Breadth of the said Cistern being 12 Foot, the Area thereof will contain 144 Foot, which being multiply'd by the Height A B or $\frac{2}{3}$ of a Foot, or 8 Inches, the solid Contents of this Cistern, or of the Water in it, will give 96 Cubical Feet, weighing (if you allow 63 Pounds to a cubical Foot of Water) 6048 Pounds.

Wherefore the Weight I, equal to so many Pounds, being put into the Scales suspended at H, the same (if you except the Weight of the Bottom W Z, and the Friction besides) will equiponderate the Water in the Cistern A B W Z; and if it were but little more augmented, it would be able to raise the Bottom W Z with all its Water A B, tho' neither the Cover or Lid A B, nor the Tube R Q S V, were over the same. And this whole Matter is obvious to every Body.

But if we proceed farther, and do also fill the said Tube with Water, which Tube being 2 Inches or $\frac{1}{6}$ of a Foot wide, and 36 Foot in Length, it will exactly contain a cubical Foot, or 63 Pounds of Water, according to the foregoing Supposition.

This being done, since the loose Bottom W Z, may be here consider'd as a Scale suspended to the Balance F H at E, upon which the Water in the Cistern A Z, and in the Tube Q R, weighs against the Weight put into the other Scale suspended at H; let any one that has not nicely observ'd these Singularities in *Hydrostatics*, or been conversant in these Matters, I say, let such a Man retire, and seriously reflect with himself, that, forasmuch as the Weight I is in *Equilibrio* with the Water in the Cistern A B W Z (exclusive of the Cover A B, and the Tube R Q); and since the whole Tube Q R does alone contain a cubical Foot, or 63 Pounds, of Water; whether he might not safely enough conclude, that the Weight I, being augmented by another Weight W, weighing considerably more than the said cubical Foot



of Water; for Instance, by adding 100, yea even 1000 Pounds thereto, the loose Bottom W Z, or the other Scale with Water upon it, might be very easily rais'd up; the rather since the same is found to hold true in all solid Bodies, and even in the Water itself, if turn'd into Ice, provided it were not frozen to the Sides of the Cistern or Tube; as is affirm'd by Monsieur Varignon, in the *Art. Lips.* 1692. p. 365.

But he that has read and consider'd the above-shewn Laws of *Hydrostatics*, will see, (*Sett.* XXXVIII.) that in the Horizontal Water-Plane A B, just below the Cover of the Cistern A B, the Plane V R is press'd by a cubical Foot of Water, or 63 Pounds; for which Reason every equal Part R e, e f, and V m, m n, of the said Horizontal Plane, according to the said Law, (*Sett.* XXXVIII.) the Water being quiescent in the Tube and Cistern, will be press'd downwards equally in all its Parts; so that therefore this one Foot of Water, or 63 Pounds, in the Tube Q R, does equally gravitate on the loose Bottom W Z, as all that Quantity of Water that would enter into the Cavity A B T P, in case the Cistern A W Z B were a perpendicular square Vessel of 36 Foot in Depth or Height, and 12 Foot in Length and Breadth.

Now we may discover the Weight which this Water would amount to, by multiplying first the Breadth and Length of the Cistern, or 12 Foot, by each other, whereby the *Area* or Base will contain 144 square Feet. This being again multiply'd by the Height Q R, or 36 Feet, makes the solid Contents of the Vessel A B T P, 5184 cubical Feet; each of which being again suppos'd 63 Pounds, the whole Mass of Water will weigh 326592 Pounds: With which Weight the loose Bottom W Z is burden'd and press'd downwards by the little Water in the Tube Q R.

Wherefore, far from rais'ing the Bottom W Z, by adding another Weight W (of 100 or 1000 Pounds either) to the Weight I in the Scale hanging at H, there wou'd be requir'd a Weight of above 326000 Pounds, only to equiponderate, or rather to put in Motion the 63 Pounds of Water thus dispos'd in the Tube Q R.

And let no Body doubt of the Truth of what has been advanced, provided the Cistern be every where strong enough to withstand this terrible Pressure. The Matter is well known to all the Moderns skill'd in *Hydrostatics*, and has been experimentally prov'd by many, as well as by us in smaller Vessels.

LX. We don't only discover these Wonders in the Pressure downwards of Fluids, but we experience them too in the Pressure upwards thereof, according to the same Laws: for since V R is press'd downwards by 63 Pounds when the Tube Q R is full, according to *Sett.* XXXVIII. every equal Part e f, &c. in the same Horizontal Plane A B will be press'd upwards with as much Weight, and consequently the whole square Cover A B, will be rais'd up with the Force of 326500 Pounds, including the Orifice V R, and that which presses on it.

We have a remarkable Example of the latter in Mr. Mariotti's *Mouv. des Eaux.* p. 106. He took a Tub A B C D, *Tab.* XXIX. *Fig.* 2. both Bottoms

whereof, A M D, and B C, were bent inwards, and making a Hole in one at E, he fix'd in it the Tube E F, of 1 Inch in Breadth, and 14 or 15 in Length, so that no Air could pass between the Tube and Hole; then filling the Tub with Water, he set two Weights of 800 Pounds P Q upon it. After that he also fill'd the Tube with Water, and found that this last small Quantity of Water did not only lift up the Lid or Bottom of the Tub, together with the said Weights, but likewise bent the said Lid outwards; all which appear'd by a little Piece of Wood I L, which was set for a Mark, and which almost touch'd the Tube at H; the said Mark at H being rais'd above I L by the said Pressure upwards.

The End of the Experimental Demonstrations, &c.

SECT. LIX. *Convictions from the surprising Force of Water.*

I LEAVE now an Atheist to consider, whether this Law of Pressure according to the Depth, and therein the dreadful Force of so small a quantity of Water, ought not to be look'd upon as wonderful, and unless Experience had prov'd the Certainty of it, whether he could have thought it credible, and whether he would not have rejected the Principles from whence it is deduced; and that he may see what the greatest Mathematicians think thereof, let him consult the *Act. Lips.* 1692. p. 365, and he will find, that M. *Varignon*, whom the whole World allows to be so great a Mechanist, gives it the Name of a *famous Paradox*; of the Truth of which he says, the modern Mathematicians are sufficiently convinced; but that they differ about the Manner according to which the same is produc'd by Fluids; and Mr. *Mariotte* calls it a *surprising Effect of the Equilibrium*. Mr. *Whiston*, *Prælect. Phys. Math.* p. 247, says of this Law (of which all these Wonders are plain Consequences) that it is a well known Rule in *Hydrostatics*, but which has hardly yet been proved either Naturally or Mathematically, concerning which he gives us his Opinions in Liquids really moved, but not in such as are stagnating; so that all the appearing Wonders are not yet compleatly solved thereby.

At least it now seems, that no Atheist can come so far without charging himself with Folly, as to imagine that he is capable of proving, that the Works of Nature must be caus'd or produced by a blind Necessity, which he is forc'd to own he does not well understand; and which far from appearing to him as necessary, he must look upon as impossible, or absolutely incredible, were it not that he was convinced thereof by Experience. And whether he can ascribe all these Wonders (that are produced with so much Constancy and Regularity, that they plainly adapt themselves to all the Consequences that can be deduced by the Mathematicians from preceding Laws) to meer Chance, I leave to him to consider.

SECT. LX. *Convictions upon another Foundation.*

I MUST add this in General, that tho' many have endeavour'd to deduce both from the Laws of Mechanics, and particularly from the following; that in order to raise a Weight of a hundred Pounds as high as one Foot, the same

Force

Force is requisite, as to raise one Pound the Height of a hundred Foot, at the same time; concerning which *Mariotte* and other Mathematicians may be consulted; yet no Body has been able without Difficulty, to explain the Manner after which Fluids, even in Rest, adapt themselves to obey these Laws to produce such Wonders; and *Mr. De la Hire* (see his *Mechanique*, *Prop.* 106. p. 331.) and *Mr. Varignon* have very ingeniously invented a new kind of Levers, the Effects of which are so very analogous to the Powers of the Fluids, that being shut up into a square Box or Chest, and put in order, gravitated or press'd against its Cover, Bottom, and Sides, after the same manner, as if the said Box were fill'd with Water; but how great an Analogy soever may be proved from hence with Fluids, neither those Gentlemen, nor any Body else, can easily be perswaded that Water, Oil, or any other Liquids, owe their aforementioned Motions to the like Machine.

SECT. LXI. *Without the Laws of Fluids, all Things would soon be in the utmost Confusion.*

IN order to be convinced of that which happens in the World by this *Law of Pressure* according to the Depth, let the Philosopher who deduces every Thing from mere Chance, or a natural Necessity, attend to the following Matters which he may have already found to be true from the Premises; or if he be an experienced Mathematician, has been already assured of it by his own Study and Experience.

Certainly he will not be able to contradict this, namely, that all the Chambers of Houses, from the meanest Cottages to the Royal Palaces, would be nothing else but fatal Caverns, and a heap of Rubbish to all that dwell in them, in case the Air should exert its Gravitation and Pressure, not like a fluid Substance, but like a Heap of small solid Bodies, and consequently, that there were no other than a perpendicular Pressure, without any Consideration or Effect of the *Law of Pressure* according to the Depth; whereby all the like Parts in the same Horizontal Plane are press'd alike, whether the perpendicular Column of Air be great or small, quite otherwise than what happens in accumulated solid Bodies. Let it be then consider'd, what Confusion and Misery would be hereby occasion'd to all Creatures that want a Shelter against the Inclemency of the Air, such as Cold, Wind, Rain, &c.

To represent this yet more plainly, let it be suppos'd that some Body is sitting in a Chamber *W* (*Tab. XXIX. Fig. 3.*) and is cover'd with a Ceiling thereof *A B C*, the Height of which, from his Mouth by which he breathes, is as *M O*; and the Height of the external Column of Air which has a Communication with that in the Chamber, is as *Q S*. If now there were no greater Pressure of the Air at *L M*, than from that Column thereof which is here represented by *L N O M*, (as it would happen if the Air gravitated like solid Matters) the Pressure thereof would be very small, and consequently its Elasticity also; as soon as the Air should be rarified by the Removal of the Pressure to which it is used to accommodate itself.

For since the Mercury in the *Barometer* *T*, is usually rais'd to 28, 29, 30, or 31 Inches, by the external Air *P Q S R*, which Mercury is fourteen times heavier

heavier than Water; if we suppose the Height of the Mercury to be 30 Inches, there will be required fourteen times 30, that is, 420 Inches of Water to balance the Air; and since Water is commonly found to be 800, 900, or 1000 times heavier than Air (supposing this last Sum to be truest) the Air being compressed in the same manner as it usually is with us, the Height of it will be 1000 times 420, or 420,000 Inches (for we take no notice here of that greater Height which it may have upwards, because of the lesser Weight it bears, and consequently is more expanded) and then we must suppose Q S to represent the aforesaid Height.

For Conveniency sake, let us now suppose N O to be the Height of 14 Foot, that is 168 Inches; accordingly the Depth of the Chamber, A D or B K must be computed at the rate of 18 or 19 Foot at least, which is higher than common Chambers are used to be; and the Pressure of the Air at L M, which is the Weight of the aforesaid Column of Air L M O N of 14 Foot, or 168 Inches, Is to the Pressure of the external Air P Q, As the Column L M O N, Is to the Column P Q R S; or As 168 To 420,000 Inches, or just as 1 To 2500.

Consequently the Pressure at L M within the Chamber, is only as $\frac{1}{2500}$ Part of that which happens at P Q by the Air out of the Chamber. Now this last raises the Mercury in a Barometer up to 30 Inches, according to which the Air in the Chamber at L M, would only raise the said Mercury up to $\frac{3}{250}$, or scarce $\frac{1}{83}$ Part of an Inch, or about $\frac{1}{7}$ of a Line which is $\frac{1}{12}$ of an Inch.

This being supposed, every one that ever saw a living Creature put under the Receiver of an Air-Pump, near which a Barometer was likewise placed, has been convinced with the utmost Certainty, that long before the Mercury subsided down to $\frac{1}{7}$ of a Line, that Creature would fall into Convulsions, and for the most part expire too.

So that from hence, and other Experiments made by the Air-Pump, (one of which we have quoted above in the XVIIth *Contemplation* from Mr. *Otho Gueric*, which had almost cost a Man his Life) it is plain enough, that if the Air in the Chamber at L M, bears no greater Pressure than that which happens to it from the Height of the Ceiling O N, all the Creatures that live either upon the Earth, or in the Air, would immediately die in the said Chamber. And that all Chambers and Houses would therefore be useless, were it not alone that this great Inconvenience is prevented by the aforesaid *Law of Pressure*, every way according to the Depth of the Fluid, to which all fluid Substances obey, and by which the Pressure in the same Horizontal Plane P M is equally strong upon the like Parts P Q and L M, whether within or without the Room.

For the same Reason it would not be possible that a Ship could go under a Bridge without occasioning a sudden Death to all that were therein. No Fish could even swim under a Bridge without being in danger of losing its Life, because the Air that is under a Bridge, would gravitate much less upon the Water; just as it happens to such Fish that are put into the Air-Pump, when the Air is beginning to be exhausted from thence, when the Rarefaction of the

the Air, and the Diminution of its Pressure upon the Water first puts them into Convulsions, and soon after kills them; that the same does not likewise happen under every Bridge, is alone owing to the Laws of *Hydrostatics*.

To this may be added, that the Air at LM in a Chamber undergoing so small a Pressure, that it can hardly keep up the Mercury in the Barometer to $\frac{1}{7}$ of a Line, wou'd become so thin, as to be incapable of conveying Sounds to their Ears, of which we have already given Instances in the XVIIth *Contemplation*; so that tho' one should be able to live in such an Air, yet no Man could speak to another therein: Not to mention that Fire will not burn in such a thin Air, nor Smoak ascend; that none of the Particles which are the Object of Smelling, could pass from any Bodies to us, besides many other Things which wou'd be occasion'd by the Thinness of the Air.

If against this it should be objected, that altho' the Air in the Chamber undergoes so little Pressure and Expansion, yet the more compressed Air would run thither from PQRS; as Water itself would do, tho' there is little or no Elasticity in it, if it were in the Place of the Air. To which we answer, that this Objection has no other Foundation but the very Action of Gravity, and the *Law of Pressure*, &c. which is only peculiar to Fluids, which in this Case we do not suppose to obtain, since we only endeavour to shew what would happen if the Particles of Air operated by their Gravity, not like Fluid, but other solid Bodies.

To illustrate this Matter, let *Tab. XXIX. Fig. 4.* be a high Sand-Bank (only consisting of solid Bodies for that Reason) and of the Figure represented here by ABCDMHN; 'tis plain then, that the Body G is pressed with the Sand above it at EFC D, and if you will, with that on the side of it at QR; but if there be in the same Horizontal Plane BH, another Body equally as big as K, which is no more than a Hand's breadth LS below the Sand, every one knows, that this K bears a small Pressure, and much less than the Body G, tho' all the Sand were contained in a Vessel equal to the whole Circumference of the aforesaid Bank; and therefore that a Man that were at G under this heavy Sand-Bank, would not be able to stir from thence, whereas, if he were at K, he could raise himself with little Trouble.

But now, if instead of this Sand, there were a Vessel of liquid Matter in the very said Form, the Body K would be pressed as strongly as G, in Consequence of the *Law of Pressure*. From whence it is manifest, that if we rightly distinguish the Action of Solid from that of Fluid Bodies, this Objection will fall itself.

SECT. LXII. *Convictions from the foregoing Observations.*

AT least, without insisting upon any farther Particulars, it will be unquestionable to such as are versed in the modern Natural Experiments, that without the Operation of this *Law of Pressure*, &c. in fluid Matters, Men would be entirely deprived of the use of their Houses, and greatest Conveniencies.

And this being so, what Reward would not a Man have deserved that had invented a Method to hinder the same, or that could have prescribed such a Law to fluid Bodies? Would not every one, even an Atheist himself, think
he

he was very much wronged, supposing he had only prevented all these Inconveniencies after a much more imperfect manner, if instead of returning him the Thanks that were so justly due to him, People should look upon him as an ignorant or foolish Fellow.

SECT. LXIII. *Even Lead itself will float upon the Water, by the Pressure thereof upwards.*

BUT if we now turn our Eyes towards that wonderful Action of the *Law of Pressure*, &c. namely, the *Pressure of Fluids upwards*; there will here likewise be visibly manifested the Glory, Power, and Goodness of the supreme Director.

Now that all Liquids which have others on the side of them, do exert a real Force, which presses upwards, has been shewn before, and may appear likewise from the Experiment of Mr. *Boyle*, which we shall represent here below, after a cheap and easy manner.

Could any Body who is unexperienced in *Hydrostatics*, easily believe that a Piece of Lead, which is so much heavier than a like Quantity of Water, should only by the Pressure thereof upwards, without being supported by any other Matter, be kept floating, and hinder'd from subsiding? And yet we see this happen, when there is no Water above the Lead, which by its Pressure might sink it down; and when the lateral Water is 13 or 14 times deeper than the Thickness of the Lead.

They who desire to make an easie Experiment thereof, may take a Tin Tube *dabf*, (*Tab. XXVI. Fig. 1.*) the lower Orifice of which, *ab*, is smooth and even; then taking a round Piece of Lead, *abmn*, the Thickness of which is about $\frac{1}{3}$ or $\frac{1}{4}$ of an Inch, and its Breadth *ab* such, as being laid upon the Mouth of the said Tin Tube *ab*, may stop the same; let there be likewise a little Hook *e*, fixed as near as possible in the middle of the Lead, and a String *ek* tied to it. Then covering the Lead *ab* with a little piece of Leather, or a wet Bladder with a Hole in the middle of it, to the end that the Hook and String may pass through, you must draw therewith the said Lead *abmn* pretty tight against the Mouth *ab* of the Tin Tube *abdf*; then holding them thus together, let them down suddenly into the Water, to the Depth *dm* (which is about thirteen or fourteen times as much as the Thickness of the Lead *am*) in a large Vessel *N TCO*, in which the Water is at the Height of *NO*; you will then find that the little String *ek*, and consequently the Piece of Lead *abnm* being free, will not sink down at that Place, but will be supported by the Force of the Water pressing upwards, and perfectly swim, according to the Experiments we have frequently made thereof.

Now that this happened only by the Pressure upwards, appears from hence, That if the Lead were not let down lower in the Water than about ten or eleven times its own Thickness, it would presently, upon loosing the little String *ek*, subside; but being placed much deeper under the Water, we found that both the Tube and the String itself being loosened, the Lead did not only not subside, but even the whole Apparatus was lifted upwards, rising and sinking like a Piece of Wood.

The Reason whereof is clear enough, as well from what has been said before, as from the *Law of Pressure*, &c. for since the Lead is about twelve times as heavy as the like Quantity of Water when it is brought to be thirteen times deeper than its own Thickness *a m* below the Water *N O*, and the Tube being held fast and still by the Hand, as the Lead is by the String, it is plain that the part *g h* of the horizontal Plane is press'd down by the perpendicular Column *p q h g*; now this Column being thirteen times as high at *p g* as the Lead *a m* is thick, the Water *m n*, which is under the Lead, will press with the same Force upwards; and since the Lead is only able to press upon the said Water *m n* with no more than twelve of the thirteen Parts, (it being but twelve times as heavy as a like Quantity of Water) it is plain enough that the said Water is press'd upwards with thirteen, and downwards with but twelve Parts; so that the Pressure of the Water upwards being greater than that of the Lead downwards, the said Lead must emerge, and cannot subside. From the said Principles it may be proved why Lead, being let down into the Water but nine or ten times as deep as itself is thick, does on the contrary immediately subside, which is likewise always verif'd by the aforementioned Experiment.

Of the astonishing Force wherewith this Pressure of Fluids upwards and downwards is brought to pass, it will not be necessary to speak now, after what has been said above in the *XIXth Contemplation*.

And from this Experiment, and from what has been shewed before about the sinking of Wood, we may plainly enough conclude, that a Piece of Wood, and much more the smallest Ship, would sink down like a Stone to the Bottom, if it were not kept floating by the Pressure of the Water upwards.

SECT. LXIV. *Convictions from hence.*

CAN now an unhappy Atheist fancy to himself, that this Force of the Water, whereby a Ship is caused to float and sail upon the Sea (for want of which the World would be deprived of the greatest part of its Happiness) is produced by Chance?

Shall we judge those to be wise and ingenious, and to have obliged the World, who have brought Ships and all their Tackling to that Perfection in which we now see them? And can it be thought, that the causing the same to move round the whole Globe of the Earth, in a manner not to be comprehended by the greatest Mathematicians, and the making it to ride upon the back of a Matter, fluid, unstable, and yielding to the smallest Impression, could ever be brought to pass, but by a Being infinitely more Wise and Good?

And tho' the perpendicular, or downward Pressure, seems in some manner to result from the Weight of Fluids; yet could ever any Body have suspected to have found therein this Law of the Pressure of Fluid Matters upwards, had not the same been demonstrated visibly and experimentally? Is there not then a wise Disposition required here, and a directive Power extending itself to the smallest Particles in fluid Bodies, which balancing them

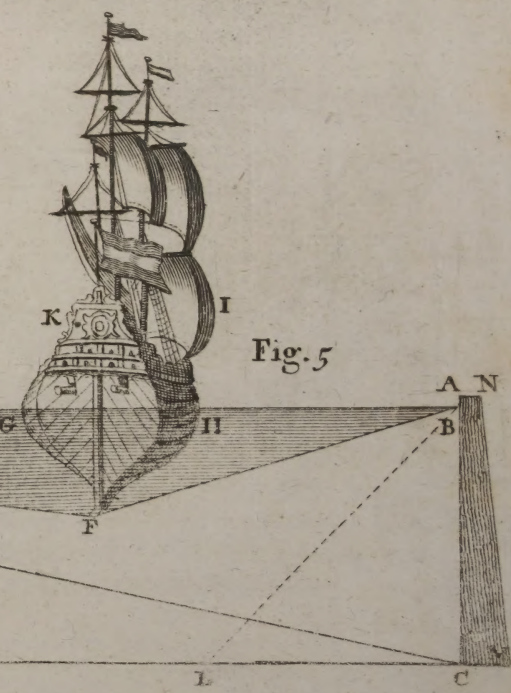
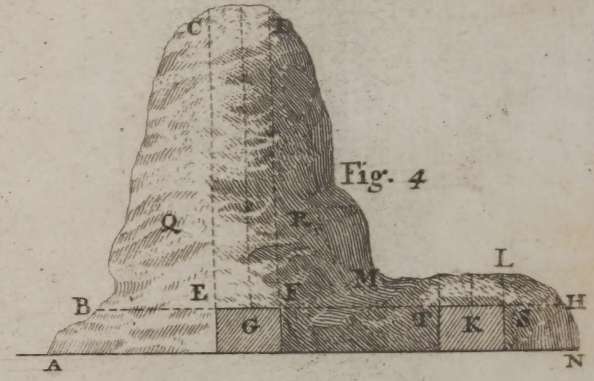
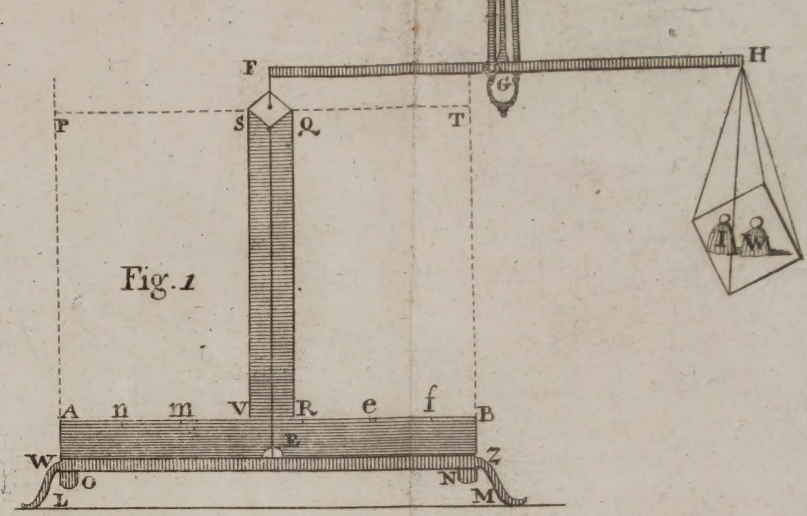
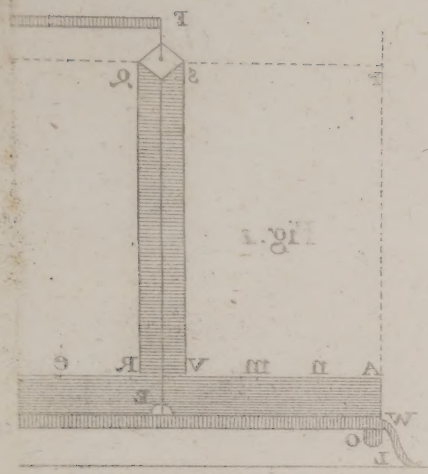
only by two equal Powers acting against each other after a most surprizing and unconceivable Manner, even when they appear to us in an impotent Rest, and seem to be perfectly void of Action and Motion, compels them to stand still? What can one see in the Water called the *Y* before *Amsterdam*, when it is not moved by any Wind, but has a Superficies as smooth as Glass, that can be compared with so unconceivable and violent a Force, by which whole Fleets laden with Cannon and other heavy Burdens, are hindered merely by this Pressure upwards, from sinking down a Hair's Breadth? And can any one reflect upon what has been said, and upon such an infinite Number of Millions of Millions of Particles of Water, all compelled to obey this Law, without discovering therein a Wisdom and Power that far exceeds all human Understanding? In which so visibly appear the great Designs of GOD in making the Seas and other Waters capable of bearing such mighty Burthens, at the same time that they are composed of a Matter that may be separated and exhaled by the smallest Force of the Sun, or any other Warmth, and drawn up into the Air, and turned into Clouds and Vapour.

SECT. LXV. *Lateral Pressure, and the Benefit thereof.*

NOW as the Wonders of the Pressure of Fluids upwards and downwards, are calculated to render Mankind happy, so likewise may this same *Law of Pressure according to Depth* (by which the lateral Pressure is also regulated) serve for a great Proof particularly; because without the same, the Sea would be unnavigable for Ships, and the Earth in a great Measure uninhabitable, so that many well-peopled Countries would have nothing to expect but the utmost Destruction. Let it be supposed for Instance (*Tab. XXIX. Fig. 5.*) that the Sea *BCDE* stands at the Height *BC* against the Dyke *ACMN*; and first that the Water being moved by no Winds, there lies a Ship still at *IFK*, and at the small distance *BH* from the Dyke: Now 'tis plain, that if Fluids were governed by no other Laws than solid Bodies, the little Water at *AHF* being much less in Quantity, and therefore in Force and Gravity, the Ship would be thrust by the greater Quantity of Sea-Water *EGF*, towards the Dyke *AB*; according to which manner it would not be able to lie still in any part of the whole Sea, without being pressed by the heaviest and greatest Quantity of Water towards the side of the smallest and lightest. We don't take any notice here of the Obliquity of such Pressures.

NOW what Inconveniencies would occur from the sailing upon the Sea and other Waters, if the same should exert their Pressure not according to the simple Laws of Depth, but like solid Bodies, according to their Quantity and Surface also?

BUT that which we now have chiefly in view is, what Dykes at *ACMN* would Men be obliged to make, if they were to be opposed against the lateral Pressure of the whole Sea *CDEB*, if the Force thereof were only regulated according to the Surface and Quantity of the Water that pressed upon the Dyke, as it happens in solid Bodies, had it not pleased the Director of all Things to subject the Force of this lateral Pressure so strictly to the



the single Height or Depth of the Water, and not to its Breadth and Quantity; insomuch that altho' the whole Sea should press against one Dyke at BC, the said Dyke would bear no greater Burthen than the Pressure of that little Water which (supposing CL to be equal to BC) could only be contained in the Space BCL, according to what we have already shewn above?

SECT. LXVI. *Convictions from the same.*

Now can any one see exerted such a Law of so many Millions of such exceeding small Particles of which the raging Ocean is composed, and which have not the least Knowledge of what they are doing, and yet act with so much Niceness at all Times, and upon all Occasions; and cannot he therein discover an over-ruling Wisdom and Power? The rather, since this Law is the only Means by which such a dreadful Collection of Waters is hindered from overflowing the dry Land, whilst the Dykes resist their whole Force, so that neither Men nor Beasts are overwhelm'd in the lower Grounds; of all which one cannot think without Emotion and Horror, when one reflects upon the Weakness of the said Dykes, with respect to the unconceivable Weight and Quantity of the Water that presses against them.

If now any living Man had found out the Secret of obliging the whole Sea to submit itself to such Laws, that how vast soever it was, but a very small part of it shou'd press upon the Dykes, would not an Atheist stand astonished at his Wisdom? And if he had invented a Method, whereby not only all Waters, but likewise the whole Ocean of Air surrounding the Globe of the Earth, and all other fluid Matters, even to the smallest Particles of them, could be bound and subjected thereto; would not an Atheist be again obliged to confess the unconceivable Extent of his Power?



CONTEMPLATION XXVII.

Of some Chymical Laws of Nature.

SECT. I. *Transition to other Laws.*

AFTER having contemplated those Laws which have long been, and particularly of latter Years are become the Object of Mathematicians, let us now pass on to another kind of Laws of Nature, which do not seem to be performed so much by plain Percussions or Strikings, as many of the first, but according to other Rules (we say *seem*, because we acknowledge ourselves ignorant of the manner thereof) by which Things being placed at a certain Distance from each other, are *attracted* (or at least do *move*) towards one another, without any visible Discovery of Percussion or Striking.

of other Parts there present ; or else such, as being placed in certain Circumstances by or near other Bodies, are *driven away*, or separated from one another ; to which Actions the Learned have annex'd the Terms of *Attraction* and *Repulsion* ; to which Laws the great Director has bound those Bodies that obey the same, after a manner hitherto more wonderful than intelligible ; and as the Naturalists have discovered the former Laws by Experiments, so the Chymists in a great measure have found out these, which likewise have lately become the Objects of Mathematical Contemplations.

SECT. II. *Experiments shewing the Operation of Acids and Alcalies.*

THE great Phenomenon of Nature, and which has given a Handle to many Disputes and Argumentations of Chymists and other Philosophers, is the famous Effects produced by *Acids* and *Alcalies*. By this last is understood every thing that ferments or boils up when mingled with *four* Bodies, and afterwards is intimately united to the same. Those who have never seen the Action resulting from the Mixture of Acids and Alcalies, would be wonderfully surpris'd thereat ; and they may easily make the Experiment, by putting in a little beaten Crabs-Eyes, which is the Alkali, into Vinegar, which is the Acid, and they will presently see the Effects thereof.

But the Motion will be much more violent, if one mixes the Filings of Iron with the Acid Spirit of *Salt-Petre* or *Aquafortis*, and attended even with a great Heater.

To shew this Effervescence in Liquids, we may take Spirit of *Sal Armoniac* mixed with melted *Pot-Ash*, or *Salt of Tartar*, in Water, and mix it with *Acid Spirit of Salt*, *Salt-Petre*, or *Vitriol*, and we shall presently discover a strong Effervescence between them.

SECT. III. *The aforesaid Salts are changed and united by Effervescences.*

NOW how many Effects result from these Effervescences, has been often shewn experimentally by the Chymists.

It is a common Consequence, that after these Motions both the Acids and Alcalies lose their former Properties, or at least do frequently seem to lose them, such as their Taste and Sharpness ; and being closely united to each other, do thereby produce a third Constitution entirely different from each of the former, such as what the Chymists call a *Salsum*, *Enixum*, *Muriaticum*, *Neutrum* or *Mixtum*, or as we call them in our Language, a *satiated*, a *Pickle-Salt*, or a mingled Salt, all proceeding from a Mixture of Alkaline-Salts, as *Pot-Ash*, or Volatile Salts with an Acid.

SECT. IV. *Experiments shewing that Acids and Alcalies precipitate, or are separated from each other.*

BESIDES this, when some of the said Alcalies and Acids already united with each other, and, as they term it, are so far *satiated*, that they will not act any longer upon others of the same Kind, and adhere so closely to the former, that it would be very troublesome to separate them again without the

the Addition of other Matter, and in some Cases even impossible to do it at all; Trials of the Operations of these Salts upon one another, have taught Inquirers that there are likewise among those Laws observed by the Acid and Alcaline Salts, some whereby this strict and close Union may be very easily, and yet as it were miraculously dissolved, and each of them separated from the other in such a manner, as if one of them thrust t'other Way, or at least quitted its hold, without any external Cause that we have as yet been able to discover.

Thus we find that one Acid seems stronger than another, and that how strictly soever some Acids are joined with Alcalies, one need do no more in many Cases than to put another Acid to it, whereby to oblige the first Acid to forsake its Alkali, and then the second will unite itself to it. The same thing does likewise obtain in Alcalies, so that one of them shall immediately separate itself from its Acid, and leave the latter to be joined thereto.

Many Instances thereof may be met with in Chymistry, but we shall content ourselves with quoting one of each.

Pour Spirit of Sea-Salt, which is an Acid, upon the Alcaline Salt of Tartar, they will effervesce, and unite themselves into a third mixed Salt, which is like the Sea-Salt: But how much Fire and Pains it will cost to separate this acid Spirit of Salt from the alkaline Salt of Tartar, is well known to those that have made the Tryal; but if you put a little Water to it, and some of the acid Spirit of Salt-Petre, the Acid of the Sea-Salt will quit its Alkali without any Trouble, and suffer itself to be drawn off by a small Fire; whilst at the same time the said Spirit of Salt-Petre unites itself with the Alkali, or Salt of Tartar, and thereupon produces a new Matter of Burning Salt-Petre, upon which if you pour again an acid Spirit of Coperas with a little Water, there will be another Separation between the acid Spirit of Salt-Petre and the said Alkali; which may likewise be extracted from thence with a soft Fire from Sand; and this third Acid, or Spirit of Vitriol, will unite itself to the Salt of Tartar, from which there will result another Salt, almost of the same kind with that which is commonly called *Tartarus Vitriolatus*.

To shew the same likewise in the Operation of several Alcalies, pour the said Spirit of Sea-Salt upon the Volatile Alcaline Salt of Animals, of Hartshorn, of *Sal Armoniac*, and the like, dissolved in Water; whereupon, after an Effervescence, they are united into a third, like *Sal Armoniac*, and the Volatile Salt will thereupon lose a great part of its Volatility and Scent in the Mixture. Now if you add Salt of Tartar for a second Alkali, it will separate the first, and discover itself presently by a new strong Smell, and the second Alkali, or Salt of Tartar, will unite itself with the Acid of Sea-Salt. They that have a mind to see several Kinds of Alcalies, the first of which, by the Addition of a second, will separate itself from the Acid, may be pleased to consult the following *Contemplation*, *Sett. VI.* besides innumerable Instances wherewith Chymistry can furnish 'em; but we shall not, nor cannot here determine any thing about the Manner used herein by the wonder-

ful Power of GOD, reckoning it sufficient that the thing is plain enough in itself.

SECT. V. *Acid Salts dispersed in many Bodies.*

It must not be thought that these Effervescences and Actions of Acids and Alcalies, have only place in Chymical Liquors, and that we therefore go too far in honouring them with the great Name of a Law of Nature; forasmuch as they, that is, one or other of them, are found in many Terrestrial Bodies, and that a great deal of that Matter of which many Bodies are composed, may be reduced to Acids or Alcalies.

To shew this in the Acid:

In *Animals* all the Milk and *Serum*, or Whey, is acid; not to enumerate any other Juices here, particularly those acid Humours which oftentimes occur in many unhealthy Creatures; or, as some maintain, are always found in the Stomach of healthy ones.

We likewise meet with Acids in *Minerals*, as in Sulphur, Copperas, Allum, Salt-Petre, Sea and Rock-Salt, in Antimony and others.

In *Plants* we likewise find some that yield an acid Spirit by Distillation; besides all those Fruits which are sowre because they are not ripe, we meet with an infinite number, which after they are come to their full Ripeness, do retain an entire acid or sowrish Taste; such as Currants, Oranges and Limons, many Apples and Pears, and the like. Besides that almost all Liquors proceeding from Plants, or other Things, by way of Fermentation, such as Beers, Wines, and the like, will turn to an Acid or Vinegar.

The *Air* itself seems to be impregnated with sowre Particles, since it will corrode and cause Iron to rust.

There are likewise *Medicinal Springs* that yield sowrish Waters, found in many Countries; See *Varenius's Geography*, Part *abs* Cap. 17. Sect. 6. of which he makes the Number in *Germany* alone to amount to about 1000; so that from hence may be inferred the Quantity of Acids dispersed throughout the whole Earth.

SECT. VI. *Alcaline Salts likewise dispersed in many Bodies.*

ONE may say the same thing of the Alcaline Salts also.

From all the Parts, in a manner, of *Animals*, there are Alcaline Volatile Salts extracted in great Quantities; to say nothing here of other Alcalies, which cannot properly be named Salts, such as Crabs-Eyes, Egg-Shells, the burnt Shells of Oysters and Muscles, Hartshorn and Bones.

Plants, when putrify'd or rotten, do likewise yield Alcaline Volatile Salts. The Smoak of burnt Wood makes a Soot, which does also afford an Alcaline Volatile Salt; and the Leaves of some Plants, such as the Palm, yield an Alcaline Spirit by Distillation. The Chymists do moreover extract from most Plants by burning, a fix'd and lixiviate Salt, which is likewise Alcaline, and of which the Ashes themselves will effervesce with Acids.

All sort of *Coral* is Alcaline, so are many *Minerals*, and will ferment with Acids; as also all *Metals*, Gold, Silver, Copper, Iron, Tin, Lead, Quick-silver,

silver, Antimony, Marcasites, the *Lapis Calaminaris*, Chalk, &c. Even a good fertile Earth will effervesce with Spirit of Salt-Petre. There are likewise some of the Mountain or Rock-Salts of the same Nature. Accordingly we are inform'd, that in the Repository of the *Royal Society* of England, there is preserved a Salt brought from the Rocky Places of the Island of *Teneriff*, the Properties of which are entirely Alcaline; and in how many Mineral Waters a like Alcaline Salt is found, may be seen in the History of the *Academie Royale des Sciences*, &c. *An.* 1702, p. 57 and 58, and 1708, p. 73 and 74; where an Enquiry being made into the Waters of *Bourbon*, *Lancy*, *Bourbon d'Archambaut*, *Bourboule*, *Mont d'Or*, *Chaudes Aigues*, *Evaux*, *Neris*, and *Vechil*, are all found to yield a natural Alcaline Salt: So that it likewise appears from hence, that Alcaline as well as Acids, may be met with in great Quantities in many Bodies.

SECT. VII. *Convictions from the foregoing Observations.*

FROM what has been said, and from a farther Enquiry into Nature, one might produce a vast Number of Experiments and Proofs, capable of convincing a judicious Reader, that there is an infinite Number of Particles in the World, each of which are constantly moved according to particular Laws, which in some Circumstances are at Rest, and of which others being brought to a certain determinate Distance, as the Acids and Alcalies, begin a regular Motion, being sometimes *attracted*, and at other times *repelled* from each other. Do not the Parts of Diamonds adhere together very closely, tho' they have great Orifices or Pores in them, and therefore touch one another with little Superficies, as appears from their Transparency? Do not we see in Fermentations some Particles which were at first still and at Rest, and afterwards begin to move among one another, in which, always following certain Laws, they one while separate, and then again unite with each other? But they who desire to see a brief Collection thereof at one View, may consult Sir *Isaac Newton's Optics*, in the *Queries at the End*, and most of the Chymists; and from thence take what they think may serve for a Proof strong enough of what has been said above.

But to such as are not so well experienced in Chymistry, to give a more familiar Instance from whence they may safely infer the foregoing Propositions, and justly conclude likewise that there is a GOD, who has not only created all these Things, but does also govern them by his Providence, according to wise Laws; let an Atheist, how great a Philosopher soever he be, reflect with himself, and consider, *First*, this Universe, as consisting of an infinite Multitude of Hundreds of Thousands of Millions of Particles, which, according to the preceeding Experiments, cannot be deny'd: *Secondly*, Let him represent to himself all these Particles, as being at rest and unmoved; which he may easily do, because Motion is not a necessary Consequence of their Existence: If now he contemplates this unconceivably great Heap of Matter, can he think it credible, *First*, That from thence are produced so many determinate, and such exceeding small *Stamina*, or Original Seed, and from them again so many glorious Machines, as are the Bodies of Men and Beasts, Fishes and Birds?

Birds? Such wonderful Structures of Plants and Herbs, divisible into such numerous Classes? So many agreeable Liquors which Men extract from the same, making use therein of those Laws, according to which the Juice of the Grape, for Instance, and others, are wont so uniformly and constantly to operate? Finally, that great and amazing Machine the World itself, with that Order and Symmetry, by which one part renders so many Services to the other, whilst not one single Particle thereof can assume any kind of Figure or Motion, but according to certain Laws prescribed to it, by and subservient to the great Designs of its Creator; nor can it separate itself from one, nor adhere to another Body, but in Subordination to the same Laws.

SECT. VIII. *The Preservation of Things proves a God.*

WE must not think that nothing but these Laws, and the infinite Wisdom by which they have been contrived, has place in the great and regular Structure of the World; for the preserving and continuing of all Things in the State and Condition in which they were first created, has likewise a Share in proving a God.

Would we see a Proof thereof, how the Great Director, from a Collection of an inexpressible Number of Particles entirely differing from each other, and which seem to us to be jumbled together in the utmost Confusion, causes only some determinate ones, and such as are subservient to his high Designs, to approach towards each other, and to unite among themselves, and with other Bodies proper to preserve, nourish and increase them according to the Laws impressed therein by his infinite Providence; let us recollect what has been said above upon this Occasion.

Is not the Air a Mixture, yea, a very *Chaos*, consisting of Hundreds of Thousands of Millions of different Particles? How many Things consumed by Fire, and dissolved by Corruption, do mingle their Effluvia, Steams, or Vapours, with the Air? How many Men and Beasts do perspire therein; yea, according to Mr. *Boyle*, almost all Bodies, not excepting Ice and Snow themselves, become lighter by Perspiration, and transmit their exhaled Particles into the Air? How many sweet-scented Flowers, how many Spices and other Things impregnate the same with fragrant Particles, insomuch that the Perfumes of them have been smelt some Leagues distance from the Islands where they grow, according to the Relations of those who have experienced the same? Every Body knows, that in Cellars where there are fermenting Wines, the Air is full of their Vapours and Spirits; which holds true likewise in all other fermenting Matters. How many watry Vapours from Seas, Rivers, Lakes, Marshes; how many sulphureous and other corrosive and poisonous Particles ascending from burning Mountains, mingle themselves with the Air? Iron, which in all Parts of the World almost, being exposed to the naked Air, becomes rusty, furnishes us with unquestionable Proofs of the Acidity thereof. With all these there is mingled an unconceivable Quantity of Rays of Light, derived from the Sun and other Heavenly Bodies; and how much Fire is elevated and retained there, appears by Lightning and other ignite Meteors.

Add

Add to all this, the proper Particles of which the Air itself is composed, and let an Atheist tell us, where he can find such another confused Heap.

Let him farther consider the Earth, and observe of what a mighty Variety of Kinds and Parts it consists. Water is turned to Earth, as we have shewn before; poisonous and wholesome Herbs, Shrubs and Trees, all the Bodies of Fishes, Beasts, and Men do likewise become Earth. In a word, whatever proceeds from the Earth, is by Corruption or otherwise changed into the same. Let an Atheist reflect again, how many Thousands of Kinds of different Compositions all this Heap of Matter might produce, every one of which might likewise be exceedingly different from all that we now see proceeding from the Earth.

In the Water we may observe the same: How many Plants and Fishes are corrupted therein? What a great Diversity of Dews fall upon it, drawing Particles of the Air along with them? How many Salts are dissolved therein? How many subterraneous Fires fill them with the Matter that bursts out of their Caverns? Water washes all Filthiness off, and how many Particles does it borrow from the Things in and upon which it has stood any while? Coffee and Tea, all sorts of brewed Liquors, the Off-Scourings of Apothecaries Shops and Kitchens; to say nothing of Minerals, of hot, bitter, and poisonous Liquors, nor yet of salt Sea-Waters; all these Things, I say, furnish us with Proofs that are obvious to every one.

To take notice neither of Fire, which does in a manner unite all Things with itself; let the Atheist represent to himself all these confused Collections of Water, Earth, and Air; and in case there were no Laws by which each kind were particularly governed, and pursuant to which these Particles join themselves with some Bodies, and again refuse to come near others, could he himself, or any Body else think it possible, that from all this Chaos, there should not once, but even frequently, and from some of them every Year, be produced anew so many different Things of particular Properties, and that it would have so happened as long as the World has lasted?

To give an Instance in one kind of thing only. Let any Body sow different sorts of Seeds by one another in the same Earth; they will stand in the same Air, they will be moistened with the same Water, warmed with the same Sun, and acquire from them all, according to what has been shewn above, an infinite Number of different Particles round about them. Now let such, who to their own Misfortune deny a Divine Providence, tell us how this can possibly happen, were it not that certain Laws obtained in all these numerous Kinds of Parts, and which are the Cause that every Particle necessary to the Growth of every individual Seed, does unite itself therewith, and to no other of different Properties, and how every Seed can always produce its own Plant of the same Kind and Virtue every Year without once failing? And why, when there are such poisonous Herbs as *Aconitum*, *Hemlock*, and the like, scattered and mingled in the same Earth with Wheat, Rye, Barley, and other Grain so useful to Mankind, there are joined only to the first, fatal and deadly Particles, and to the latter, only wholesome ones? And why an Apple-Tree never bears Pears, or a Vine, Cherries?

SECT. IX. *All Kinds of Philosophy do, or must acknowledge Laws.*

LET the most experienc'd Philosophers be called upon, and let them tell us themselves, if they will declare their Sentiments impartially, whether, without acknowledging these Laws and a directing Providence, they can make these and such like Phænomena (for there are many such in the World) the necessary Consequences of the Hypotheses upon which they found the Science of Nature.

Some have thought upon a Magnetical, and other Kind of Attractions; but these lay down one sort of Laws.

Others suppose a certain kind of *Ferment*, as the Chymists stile it, in the *Stamina*, or Principles of Seeds, of which there can be no other Notion formed, than that they are Parts figured after a particular Manner, and moved according to certain particular Laws, and which unite themselves with some Bodies, and separate from others.

Finally, Since both these Hypotheses have been rejected of later Years, those that have philosophized more rationally, have laid down, that there are Pores or Orifices in Seeds of certain Figures, through which only are admitted Particles of the like Figure; which, according to the Opinion of others, who will not own a Direction, because that leads them to a God, may come to pass by Chance or Necessity, since there seems to be nothing more requisite thereto, than that these Pores should be disposed to receive those little Particles as soon as they are put into Motion. But according to this Hypothesis there might, *first*, not only all kind of Particles be admitted into the Pores of the Seed, provided they were but small enough; but likewise, *secondly*, there would hardly be one Seed capable of growing, and but very few Particles enter into the same, save only round ones, if nothing but meer Chance obtained therein, as Dr. *Pitcairn* has expressly and mathematically demonstrated in his *Dissertations*; since the same kind of Particles must always present themselves before the same Pores, and exactly after the same manner, if they would gain Admittance. But let us shew this by a more familiar Instance: Suppose any one should undertake to throw a Dye through a square Hole, through which it could but just pass; must he not stipulate, in order to have an equal Chance of winning or losing, to repeat his Throw a great many Times? So that if something like this should be the true Cause of growing of Plants, and all the Particles of the Figure of a Dye should always pass through the square Pores in a Seed; there must at least in this Case, as much as in any other, be a Rule or Law, according to which each Dye must be disposed when it comes against the Orifice or Hole.

We do not here dispute, whether any thing of all this, or somewhat else, be the real Cause, that among so many Thousands of various Particles, those only approach to, or are attracted by each Seed, which are most proper to compose the particular Plant in its kind; but our Design was only to shew, that without acknowledging a Divine Direction, whereby all Things are moved according to the requisite Laws, whereby some Things are made

to approach, and others to recede, and which are extended to every one of these unconceivably small Atoms, no other Hypothesis has hitherto been offer'd, whereby the Growth of Plants and many other Things could have been resolved. In short, to obviate all the Evasions of Atheists, let us recollect from what has been said above, that among the Thousands of Kinds of Animals and Plants, there is not one only to be found which was not at first formed of an exceeding small *Stamen*, containing all the Parts thereof in Miniature, and from whence, by Expansion or Unfolding, and by Covering or Cloathing with adventitious, particular, and determinate Matter, all Plants, all Men, Beasts, Fishes, Fowls, and every other living Creature are produced; as is well known by the general Experience of those that use Microscopes. Let then the Atheist or Sceptic think with himself, whether he can reconcile all this to a mere and accidental Concurrence of ignorant Things; and these curious little Forms and Figures, in which all that is necessary to so many wonderful Purposes in great Bodies, are compris'd in a much smaller Quantity than a Grain of Sand: I say, let him make all these Things agree with those necessary Laws, that operate without any wise Direction or View. After so many illustrious experimental Proofs of the Wisdom of an adorable Creator, no reasonable Person can require any more; especially if it be true (as some great Men think it very probable) that in all these *Stamens*, how small soever they may be, those of all others that are to be produced to the end of Ages, are actually to be found in their determinate Figures.

SECT. X. *The Opinions of some Philosophers about Fertility.*

I DON'T know, whether it may not be thought proper by some to add to all this, one Notion more, which appears very plausible to many, but yet seems to require a farther Examination and Trial before it be entirely admitted for certain: But since the same has been entertained by several Great Men, and seems to have some Analogy with the Chymical Operations and Action of the Parts of Matter upon one another, and especially since the thing carries along with it a great Proof of God's Providence; it may perhaps be of use, if we here subjoin a few Observations that may set the same in some kind of Light; and, it may be, also excite thereby some of the Learned to look farther into a thing that is at least worth double their Pains.

It consists in the Inquiry of what may properly be the Means which the Gracious Preserver of all Things makes use of to render the Earth fertile, and to cause Plants to grow powerful therein.

Now that which may be experimentally pronounced upon this Matter, according to the Opinions of many Naturalists, is, that the Nitre of the Air is the Cause thereof; to which perhaps one may add, that since Nitre, or Salt-Petre, is alone and of itself an unactive Matter, there must something else concur to put it into Motion; much after the Manner same as it happens to the Acids and Alcalies, which, when separate, are at rest, but being put together, will effervesce and boil up with each other. The same happens by the Mixture of Salt-Petre and Brimstone in Gun-powder.

SECT. XI. *The Air seems to abound with Salt-Petre : Seven Experiments shewing the Probability thereof.*

Now to prove, if not with entire Certainty yet with great Appearance of Truth, that either Salt-Petre is in the Air, or at least some other Matter, which being much of the same Nature, meets sometimes with something else in the Earth, whereby between them real Salt-Petre is produced, appears from the following Experiments.

I. That the Earth may be mixed with such Matters upon which the Air will operate ; such as the Filings of Iron, the Urine, Dung, and Blood of Animals, lixiviated Chalk and Ashes, &c. and that from such Mixtures, after they have been exposed naked, by being turn'd up for several Months, to the Action of the Air, a remarkable Quantity of Salt-Petre may be extracted.

But forasmuch as great and learned Men seem to differ about this Aërial Salt-Petre, I thought fit, for greater Certainty, to make this Experiment, and found by the Event, that such an Earth after being managed properly, yielded in a Month's Time about three Pound of very good raw Salt-Petre. This has been touched upon before, so that what is here said, may be the more safely depended on, and the rather, if we add what several have affirmed to be experimentally true, namely, that the Earth from which Salt-Petre has been once extracted, will, after a while, be again impregnated by the Air with the same.

II. Since every Body may find, that by letting Blood run out of a Vein upon Water in which Salt-Petre is dissolved, the black or dark Colour thereof, will be immediately turned into a bright Red ; and the *Serum* or Whey of the Blood become as transparent as clear Water, tho' it retains its nutritious, or at least solid Parts ; which by dropping a little Spirit of Salt-Petre upon it, may likewise be separated therefrom ; yea it is known that black venous Blood being exposed in a Vessel or Porringer, is often red at the Place where the Air touches it ; and that even upon taking off the upper red Part, the Black which was under will likewise assume a bright red Colour : I shall not here dispute, whether the Air is mingled with the Blood in the Lungs, because this is doubted by some Philosophers ; but however it is plain from these two Tryals, that Salt-Petre and Air do act uniformly upon the Blood ; and therefore it is in some manner probable, that the Air is impregnated with Salt-Petre.

III. It is known to the Naturalists, that a great deal of Salt-Petre may be made from Blood, (See *de Stair de Nitro*) if now it be true, that in breathing, the Air is continually mingled with our Blood, one would be apt to imagine, that it leaves a great deal of its nitrous Quality therein, which may afterwards be extracted.

IV. Since refined Salt-Petre being held in a warm Hand, will snap and break, which perhaps might be occasioned by the Air that was in it ; I took a Piece of Salt-Petre and threw it into a bright Lye, in which there is never any Air ; then putting it into the Air-Pump, I observed a great

Stream

Stream of Air-Bubbles coming out of the Salt-Petre, and ascending thro' the Lye.

Now whether from this Experiment it may be concluded, that the Parts of Air and Salt-Petre are easily united and adhere close together, because the Salt-Petre has so much Air in it, tho' chrySTALLIZED in Water, and reduced to little Tubes, I leave to the Judgment of others: It might however in some manner lessen the Difficulty some People make, as if Salt-Petre were too heavy, and not volatile enough to keep itself up in the Air.

V. This seems however to be entirely removed thereby; forasmuch as the Observations made by the new Burning Glasses shew, that Salt-Petre held in their Focus, entirely evaporates, and so mingles itself with the Air, *Hist. de l' Acad. &c. 1699. p. 114.*

VI. All Metals, such as Silver, Iron, Copper, Lead, which are dissolved by the Spirit of Salt-Petre, especially those upon which it acts with the greatest Force, as it does upon Iron, seem to rust in the Air; only Gold, which a simple Spirit of Salt-Petre can't touch, is not so much exposed thereto: All which gives a handle to a Conjecture, that if there be not Salt-Petre itself, there is at least some Matter of the like Nature in the Air.

VII. A yet farther Proof that there is something nitrous in the Air, seems to result from the Pains in the Head, Faintness and Dispositions to vomit, which often appear in some Women when they are in close Rooms, where a great many People and Stoves are. To be satisfy'd of this Consequence, the Reader may be pleased to recollect what we have shewn above in the VIIth *Contemplation*, namely, that Flame and humane Respiration are maintain'd by the same kind of Air-Particles; for which reason, the Air shut up in a Room where a great many Stoves are burning, and a great many People breathing, must be very much divested of those Parts, and be the occasion that some weak Women are disorder'd thereby. Now that these Parts are properly Nitre or Salt-Petre, which being render'd by the Warmth of the Fire and Breathing, unfit to discharge its Functions, seems to appear from hence, that Women thus disorder'd, cannot recover themselves by any better Means than I know of, especially when the fresh Air won't do, than by the use of a Nitrous Salt dissolved in Water, of which I have seen many Experiments, either by putting a little Salt-Petre or *Sal-Prunelle* in their Mouths, and letting it dissolve gently, and swallow it down.

SECT. XII. *Salt Petre seems to come out of the North; proved by three Experiments.*

SINCE now the first of the Experiments seems to prove, and the other to make it very probable, that the Air has either Salt-Petre in it, or something of a nitrous Quality; it will appear in some manner from the following Experiments, that the same, at least on our side of the Equinoctial Line, proceeds chiefly from the North.

I. Not to mention that the Air is cold to a great Degree in the Northern Parts of the World, (as for the South Pole, we take no notice of it now)

nor that Salt-Petre does after a particular manner produce sensible Coldness, as we see in putting of Bottles of Wine in Summer-time in Water, and throwing a good Quantity of Salt-Petre into it, which chills it so much, that some have thought that one might freeze Water thereby, but that I shall not determine: From hence it may be consider'd, whether that Air which makes so many Mountains of Ice in the frigid Zone, and keeps them always undissolved, must not greatly abound with Salt-Petre.

II. To render this the more probable, we shall add what the Learned *Hamborgius* relates from the *Ephem. Barom.* of Mr. *Bernard Ramazzini*; that Gentleman says, that the Excrescence of Salt-Petre from old Walls made of Mortar and Stone, does mostly appear in Winter, and when the Northerly Winds blow; and that those who make it their Business to gather Salt-Petre, do at that time particularly sweep the Walls; and that they get more of that Matter from Walls that stand to the North than to the South; which seems to prove plainly enough, that besides the general Impregnation of the Air with Salt-Petre, the Northern Air does mostly abound therewith, and that it is frequently brought from those Parts to us.

III. Now whether it may be inferr'd, that upon account of nitrous Salt, the Northerly Winds make the Air heavier, and that upon the turning of the Wind to that Corner, the *Mercury* does often rise in the *Barometer*, as many, who have writ upon this Matter, affirm, I shall not here inquire after.

Now whether the Air be render'd heavier by the Northerly Winds (which bring along with them from the cold Regions, a thick and compos'd Air towards the South, as appears from the *Thermometers*, in which we may observe, that Cold compresses the Air, and as appears likewise by the Refraction of Light, which is affirmed to be greater in the North) or whether such Gravity of the Air proceeds from the Salt-Petre wherewith it is impregnated, or for other Reasons: They who use *Barometers* know very well, that the heavier the Air is, and the higher the Quicksilver rises, the less rainy and the more dry Weather may be expected. See the *Act Lips.* 1696. p. 213. from whence therefore, besides other Circumstances that may be peculiar to the Country of the *Jews*, the Reason in general may be assigned of that Expression in *Solomon's Proverbs*, Chap. xxv. ver. 23. *The North Wind driveth away Rain*, since by the greater Weight of the Air, the watry Vapours remain floating therein, and cannot descend in Rain.

SECT. XIII. *Salt-Petre becomes active by those Particles in it that are Sulphureous, shewn by Experiments.*

BUT since Salt-Petre seems to be very unactive in its own Nature, inso-much as when put into a Melting-pot over the Fire, it does not exert the least active Faculty, even with great Heat; it may be necessary to examine a little more closely, what it is that renders it Active (as Acids and Alcalies working upon each other) and how it comes to produce such Wonders.

Now the Bodies which are more peculiarly proper to produce such an Effect, are all such as come under the Denomination of *Sulphur* among the Chymists; to which belongs common Sulphur itself in the first Place, and every Thing else that has Sulphur in it; such as Antimony, Turf, and Wood-Coal; and in general, all that has Fat or Oil in it, such as Tartar and the like.

Thus we see that Sulphur or sulphureous Bodies, thrown into melted and glowing Salt-Petre, or else being mingled cold with the same, and set on Fire, are put into violent Motions, and the Mixture often into a sudden and consuming Flame: So likewise we find that Tartar mingled with a like Quantity of Salt-Petre, will be kindled with the smallest Fire, and burn so long, till the Oleaginous and other Parts of the Tartar are evaporated; after which there will remain a white Alkaline Salt, which is therefore called *Salt of Tartar*. After the same manner we see dissolved Salt-Petre mixed with beaten Charcoal, or Turf char'd, and thrown into the Fire, become active, and cast out Flames; where being continued till no more Flame is perceived, the Chymists make of it an Alkaline Salt, which they call the *fixt Salt of Nitre*: But whether it may not more justly be termed the *fixt Salt of Coals*, for the same Reason as t'other is called the Salt of Tartar, I leave to the Learned: At least, how very active Salt-Petre is render'd by Sulphur and Coals, Gunpowder furnishes us with a well-known, or rather with a wonderful and terrible Instance.

It must not be thought that these Matters cannot be kept up in the Air, as not being fine and small enough, because we have shewn before, that besides a great many other different Particles, there are likewise those of Sulphur found in the Air. Thus we see, that in the *Mediterranean*, and other Parts of the World that are more Southern than we, there is very great and frequent Thunder and Lightning, of which in *Greenland* (as I have been informed by one that has been often there) and here with us in Winter, very little is observed. Now that this is occasion'd because the Air abounds with more Sulphur in the former Regions than in the latter, (whereas in *Greenland* there seems to be more of Salt-Petre only, which passing from the Northern to the Southern Part, produces these Effects in Conjunction with the sulphureous Air) is allowed by many as a very probable Thing.

It has been likewise shewn above, that the Rays of the Sun operate upon Salt-Petre, and render the same Volatile; for that those Rays are Corporeal, and do likewise even bring along with them a Matter that gravitates, appears from the Experiment of Mr. *Homburg* about the *Regulus* of Ising-Glass, as the Chymists call it. See the XXIVth *Contemplation*.

I know not whether I may not here add, that in the Year 1711, having gathered some Dew about the latter end of *May*, and kept it a while in a great Glass Vessel, I caus'd the same to evaporate, in order to try whether there were not Salt-Petre in it, as some affirm; but found no Salt at that time, but only a little reddish Matter pretty near the Colour of the *Scoria* of *Regulus Antimonii*; which being sprinkled upon a glowing Coal, would not burn as Salt-Petre is wont to do; but when thrown into an earthen Vessel, in which there

there was glowing Salt-Petre, it flamed visibly, but however pretty faintly in comparison of common Sulphur.

I cannot here determine exactly of what Nature that Matter was, there being too little of it to bear a further Examination; but however, I judge it to be of a sulphureous Nature, by its flashing with melted Salt-Petre; at least it was plain enough that Salt-Petre acted upon this, and this upon Salt-Petre.

It likewise seemed as if we might conclude from thence, the Operation of the Solar Matter brought to us by the South-Winds upon the Aërial Salt-Petre, since we find that a glowing Coal of Turf being placed in a hot Sun-shine (out of the Wind, which would otherwise blow it up) is extinguished, and ceases to burn, just as if it were put into a Quenching-Pot. The Reason of which seems to be, that the Salt-Petre of the Air, which is otherwise the principal Cause of our Turfs burning, is render'd unfit by the Action of this Matter, which proceeds from the Sun, to continue the Fire of this Turf-Coal as well as before. Now that this is true, and that Salt-Petre is a great cause of the burning of our Fires, appears from hence; because, that in the strong Frosts of Winter, when the sharp Northerly Winds reign, which have been proved before to be impregnated with a great deal of Salt-Petre, our Turf-Fire burns much brighter, and is much sooner consumed (as Coals are upon which one throws Salt-Petre) than in Summer, when the Air has not so much pure Salt-Petre in it.

SECT. XIV. *Salt-Petre in Conjunction with the Rays of the Sun, does likewise render the Earth fruitful, shewn by an Experiment.*

THUS we find also, that the Action of Salt-Petre, and the Rays of the Sun, do contribute very much to Fertility. Not to relate here, for a Proof, Mr. Homberg's Experiment in the *Transactions* of the French Academy, 1699, p. 75, 76. which shews the same of Salt-Petre when diluted in Water, and poured upon Earth: One may likewise make another Tryal, by steeping Grain or Seeds for some Hours in two Pints and half, for Instance, of Water, in which an Ounce of the best Pipe Salt-Petre has been dissolved, and so proportionably; and it will be found that these Seeds will be much more fruitful than any other that have not thus been infused in Water unimpregnated with Salt-Petre. I saw the Experiment thereof in the Year 1711, when some French-Beans that had been steep'd were observ'd to grow a third Part higher than others; and have treated some Seeds of Purslain in the same manner: it grew so large, and so strong, that a learned Gentleman, and one that was well versed in Plants, could not forbear asking what it was? and said, he had never seen such Purslain in his Life.

This Property of Salt-Petre was likewise known to those of the Antients that have writ upon Agriculture: But to shew farther that which was proposed, namely, that not only Salt-Petre, but that which likewise proceeds from the Action of the Solar Matter thereupon (allow me so to name either the Sun-Beams themselves, or that which they bring along with them) does render the Earth fruitful: It will be sufficient in the first Place, to consider how much the Sun contributes to the Growth of Plants, this being unknown to no Body; and

and it will give some Light to the Matter, to mention here that which happen'd to me about the latter end of *May*, in the Year 1712; for having sown Purslain, some of which had been steep'd in Salt-Petre Water, and other not, at the same Time and Place; some Days after which the Nights were so cold as to make Ice; and I having found by former Experiments, that in the strongest Frosts there would be found no Ice in Lye, and little or none in common Pick'es; that a Water in which there was as much Salt-Petre dissolved as could be, being set within-side, or even without-side of the Window, in a little Bottle close to the others in which the Seeds were, that Water was so strongly frozen as to crack the Glass, the Parts of which were separated more than the Breadth of a Straw; it came into my Head, whether, since the Salt-Petre Water froze so easily and so hard, the Purslain, the Seed of which had been steep'd in the like Water, might not be killed by this Frost, especially since the Sun had hardly appeared during all that time, which was very cold; and going to the Window to see, I found that that Seed which had been sowed after the common manner, was green, and that that had lain in the Salt-Petre Water, much more advanc'd in those Parts that remained alive; but that most of it was frozen and dead.

From hence I think we may infer, that in order to make Plants grow and flourish, not only Salt-Petre, but likewise something that proceeds from the Sun is requisite thereto; to the end, that by their reciprocal Action, they may concur in the producing these Effects upon the Earth, and the Plants thereof.

Besides, that this seems to be further confirm'd by a common Experiment observed by some Husbandmen, namely, that when in the Month of *March*, and the beginning of *April*, North and North-easterly Winds blow a long while together; and thereupon it is apprehended, that they shall have a bad Year, and that the Grass by reason of the Cold does not spring up, there is oftentimes a very good Crop, and even an early Hay-Harvest; for some Years I observed it, and found it always to be true, especially in the Year 1712, when by reason of the frequent Northerly Winds in the Spring, somebody said to me, that he feared it would be a bad Season, and that Hay would be scarce; to which I answer'd, that I had often found the contrary, and that if it were but followed with a good warm Sunshine, the Grass would perhaps be early ripe, and there would be a great Quantity of Hay, which likewise happen'd.

Now they who allow the Probability of what has been advanced, may easily infer the Cause from thence, namely, that the frequent Northerly Winds might bring great Quantities of Salt-Petre to us, which being succeeded by the Southerly Winds, and the Solar Matter that accompanies them, a great Quantity of those Particles which act upon each other, and contribute to Fertility, is then found in our Air; tho' on the other side it may so happen, that the Northerly Winds shall be so strong and lasting; and the Southerly so weak; and the warm Weather so little, that the Aerial Salt-Petre may be as prejudicial to the Fruits of the Earth, by reason of its too great Plenty, as the common Salt-Petre (the Experiment whereof is mentioned

above) which being used in too great a Quantity, killed the Plants. With this agrees the common Proverb of the Husbandmen, confirmed by numerous Experiments, that *a Peck of March Dust is worth a King's Ransom*. That Month being commonly dry with us when the North Winds blow, by which the Air is render'd so heavy, that the watry Vapours will remain floating in them, and cannot descend in Rain; which with Southerly Winds are wont to come plentifully down at the same Season.

SECT. XV. *Convictions from the foregoing Observations.*

I HAVE dwelt the longer upon this Matter, not only because the above-mentioned Experiments require to be expressed and proposed with some Clearness in their Circumstances; but particularly in order to stir up others that have Inclination and Conveniencies, to inquire more narrowly what it is properly that renders Lands fruitful, and makes Plants grow more freely; to the end that they may either corroborate what we have here said, by farther Experiments; or otherwise, if they find that the Works of Nature exert themselves after a different manner, they may communicate their Lights to the World; since there still seems to be wanting Numbers of Experiments; for Instance, how to order such an Earth, or such Seeds, so as that in a few Hours a Sallad, or other Plants fit for use, may be produced; or again, that each Seed may at the same time put forth all the Seed-Plants contained in it, and make them grow equally, by which means the Fruits of the Earth might be multiplied; and such like Experiments: At least every one will readily agree, that this is a Matter, the Inquiry into which may not only much more illustrate our Knowledge of Nature, but likewise be very beneficial to Mankind.

In the mean while, since no body can be ignorant that the Air is the Magazine or Treasury, from whence that which renders the Earth fruitful is communicated thereto, as the frequent plowing and turning up the Earth, and exposing it to the Air, has shewn experimentally for many Ages; can it be thought that it comes to pass without a wise Providence, that there has never been any Want in the Air of such Particles as are fit for that Purpose? That the Waters of Rain, Dew, and Snow, falling down through the Air, are impregnated therewith, in order to carry such Particles along with them, and to insinuate them deep enough into the Earth, so as to fertilize the same, and to dispose it to furnish all living Creatures with Food and Refreshment?





CONTEMPLATION XXVIII.

Of the Possibility of the Resurrection.

SECT. I. *The Objection of the Sadduces answer'd by our Saviour, Mat. xxij. v. 29.*

I SHOULD here have made an end of contemplating the Laws of Nature, because an Inquiry into all those, to which the Study of Nature, particularly Chymistry, leads us, would take up too much of our time here: But since it may seem to contribute very much towards the illustrating a Matter which is of great Importance, I shall attempt to set that matter likewise in some Light, tho' it is seldom handled upon Natural Principles. To enter therefore upon it:

It is well known, that among those unhappy Persons who deny the GOD that made them, there be many who are wont not only frequently to ridicule the Confession of Christians about a Resurrection, but likewise to oppose the same after all imaginable Ways; and that others, who seem to treat this matter with more Reason and Decency, are likewise accustomed to form some Objections against it, by which they think they do sufficiently prove the Impossibility of a *Resurrection*.

I know very well, that in order to cut off all Difficulties and Cavillings raised against this Article of our Creed, by those who acknowledge a GOD; and believe the Holy Scriptures, nothing can be more strongly returned, than what our Lord was pleased to answer to the *Sadduces* who deny'd a Resurrection: *Ye do err, not knowing the Scriptures, nor the Power of God, Matt. xxij. v. 29.* That is to say, the Word which you admit to be Divine, says so; and no body ought to doubt, whether the Power of GOD be great enough to perform what he has said.

SECT. II. *It is not a greater Miracle to Raise a Body, than to Create it.*

BUT since we have here to do with a sort of deplorable Disputers who have no Reverence either for GOD or the Scriptures, and who think that they are able to prove from their Philosophy, the Improbability, if not the Impossibility thereof, I have been of Opinion, that altho' the Certainty of a future Resurrection can only be deduced from the Word of that GOD who never deceives any one, and that the Manner of it must likewise be referred to his Wonder-working Power; yet that it might be perhaps useful to some, to shew here, that all the Objections which they can raise against it, are far from having any Strength in them; but on the contrary, that the few as yet known Laws of Nature and Appearances are more than sufficient to answer them all,

at least all that have ever occurred to me, and to put the Possibility of the Resurrection, the Proof of which is our present View only, quite out of doubt.

To begin therefore : Let one that denies or doubts of the Resurrection, tell us whether he is not forced to allow, that all the Food of which his Body consists, as well as the Bodies of all his Progenitors, does proceed from the Earth, or rather is nothing more than a metamorphosed, or transformed Earth : (If he denies this, let him read what we have said thereupon in the first and following *Contemplations*.) 'Tis a plain Consequence then, that his Body likewise proceeds from Earth.

And this being so, it is no more strange that his Body which was once Earth, should be raised again from the same, than that it had acquired or received its first Figure from thence. What Impossibility is there, that so wonderful and dreadful a Power, which made use of the Earth to form a humane Body before there was any such Being in the World, without its Knowledge, without its Concurrence, and after such a manner as is unconceivable to him and all other created Beings, should now again think fit to make use of the same Earth to the same purpose, and raise him up again from the Dead ? Let this Philosopher suppose with us, that a Man were born and brought up in a Place where he should be entirely ignorant of the Nature of his Food : If now another Person came and shewed him a Lump of Earth, out of which Rye and Wheat, or what else he might have used for Food, were produced ; and if he told him, that his Body did not only proceed from, but was likewise maintained by this Earth ; would not this Denier of the Resurrection think, as we do, that such a Man would make as many Scruples in admitting the same for Truth, as others now do when we tell them, that their Body shall once again proceed out of that Earth into which it is turned after Death ? And would not likewise, even the most learned Enquirer of what happens in the World, be as much amazed at the Manner after which his Body is formed out of, and sustain'd by Earth, were it not that the Custom of seeing frequently how a humane Creature is born and nourished, but never how he rises from the Dead, would seem to make this matter more intelligible to him, and, as it happens with customary Things, make him look upon the former with no Wonder ?

SECT. III. *Even the common Formation of Bodies is less credible than the Resurrection.*

LET one that denies the Resurrection tell us, whether the Parts of which his visible Body is composed (for as for the exceeding small *Stamina*, we shall take no notice of them here) were not as much scattered over the whole Earth about 5000 Years ago, as they will be many Years after his Death, or at the End of the World ? (See concerning this Matter more largely in the following *Contemplation*, Sect. V.) And whether it be more impossible in this last Case, than in the first, to collect the Parts so dispersed, and to bring them into Order.

Again,

Again, if he were ignorant of the Manner by which the Procreation of Animals is performed, and had had no Opportunities of seeing the same, let him ask himself whether he should admit it as a Truth, that a human Creature, for Instance, lying so many Months in a Liquid Matter, like a Fish in the Water, could be able to live; whereas now the same Creature, if kept but a few Minutes under Water, would perish? And would not he think, that from hence he might alledge many Reasons, why 'tis more probable that a Man should be produced, like a Plant, out of a Seed, or at least after some other Manner that does not so directly contradict Experience? And yet he sees this comes to pass constantly, and always after the same manner, without any Variation. Can now the Resurrection of the Dead appear to him more wonderful, or even so much? Since in this last Case it is only required, that a Body should be produced from the same united Parts; and the Manner after which a Man is now formed does besides this seem likewise to run counter to several plain Experiments; by which it appears necessary, that we should breathe in order to live; whereas we have nevertheless sufficient Cause to affirm, that a Child can live several Months in its Mother's Body without Respiration.

This seems to be sufficiently proved, forasmuch as the Lungs of a Child that is *stillborn* will sink in Water. *Bergerus*, p. 481. gives us an Experiment thereof, and tells us, that the Lungs of a Child born dead, being put into an Air-Pump, will not swell, and when thrown into the Water will subside; the quite contrary of which must have happened, if the Child had been born alive, and had remained any time in the Air, since such Air is never perfectly discharged again from the Lungs, but there will always remain a sufficient Quantity thereof to cause the same to swell, and to hinder the sinking. Accordingly we find, that a Piece of the Lungs of a Beast newly killed, being emptied of Part of its Air by the Pump, will contract itself and sink deeper into the Water than before; but however, it will not subside to the Bottom till, after much Pumping and a good deal of Trouble, the Air be quite exhausted.

SECT. IV. *The First Objection answer'd, namely, That we have no Parents in the Resurrection.*

BUT to proceed; we must not stop at this Objection, which to understanding Persons is too vulgar, *viz.* That the Resurrection does therefore seem incredible, because when we came into the World, we had Parents to whom we owed our Birth, and that there were so many proper Means at hand upon that Occasion, but that the same will all be wanting at our second Birth or Resurrection.

Since all that a good Logician can prove from thence is, that there is a Power and Wisdom capable of providing Means for the Generating of human Creatures after this manner; now what Reason can be given, that the same Power which has been able to do this after one manner, cannot make use of other Means for the same Purpose? The rather, since we see that God, to manifest his Wisdom likewise to those that hate it, is wont

to execute the same Purposes in numberless Ways and Methods. It would be unnecessary to repeat Instances here of all kinds of Animals, having done the same largely in the beginning of the XXIIId. *Contemplation*, where we have given an Account of their Motion, Nourishment, and Production, in respect to which the Instruments of each kind of *Fishes*, *Birds*, and *Beasts*, are almost all differing from each other, and yet they are all procreated, nourish'd, and do move themselves from one Place to another.

So likewise when we contemplate the *Plants*, how various are the Ways of putting forth and growing among them ! Some grow in Earth, and that oftentimes in one only determinate and particular Sort ; others require another kind of Soil ; some grow upon the Water, and some even under Water ; one in a warm Climate, and another in a cold ; some are propagated by the Seed ; some by a Branch taken off from the main Plant ; a third by Setting ; a fourth by Grafting ; a fifth by many of these, and perhaps yet different Methods : And thus are the Views the Great Creator, of causing Plants to continue in their Kinds, executed after so many different Ways.

This being so, what Impossibility is there that the same Power which produced the Bodies of Men once before by the Means of their Parents, may not perform the same again by other Means ? And if we only suppose, that this Great Maker can use as many Ways as all Men can invent, (wherein nevertheless his Power does far exceed all human Inventions ; as is plain to those that are wont to inquire into his Works, where they daily learn something new, that perhaps never before entred into their Thoughts) no Body will easily deny the same ; forasmuch as he would pass but for a poor Philosopher among the Atheists, who should not imagine himself capable of forming an Hypothesis, whereby human Bodies, by a different Disposition and Motion of Parts might be produced after a different manner than now they are.

SECT. V. *The Second Objection, from the Smallness of the Parts after Corruption, answer'd.*

THOSE that deny the Resurrection do again think the same impossible, because our Bodies being dissolved by Corruption into so many and so small Particles, it does not appear credible to them, that they can be all again replaced in their necessary Order, nor the *proper* Body thereby restored to its former Figure. But will they therefore doubt, whether a good Anatomist can put all the Bones of a Skeleton, or a good Clock-maker all the Wheels and Pieces of a Watch, tho' jumbled together without any Order, into the same Structure again, so as to compose the very same Skeleton and Watch ? If therefore we do but suppose that the Great Creator of the Universe is endowed with only so much more Wisdom and Power than an Anatomist and Clock maker, as the Structure of a human Body is more noble and curious than a Skeleton or a Watch, what Difficulty can there yet remain ? For that we do not herein ascribe too much to that Adorable Being, but on the contrary think of him much too meanly, and below his great

great Perfections, by such a Supposition, may appear from hence; that if all the best Workmen in the World should lay their Heads together, there would not be Wisdom enough in them, (to say nothing of their Power) to put in order the Body of a Flea, or any other Insect, or even any little Seed of the smallest Plant, so as to compare for Excellence and Contrivance with any one of those which we daily observe to proceed by Millions out of the Hand of this Great Artificer: the rather, because, as has been shewn before, the most minute Particles, even those of Light itself, are governed by a Power which extends itself to all Things, and they are subject to certain and fixed Laws, even when they appear to be in the greatest Disorder. Having often seen the Picture of a Man so accurately formed upon a white Cloth, or Paper, in a dark Chamber, it occurred to my Mind as an agreeable Type of the Resurrection; at least it appeared from thence, that the Rays of Light reflected from the real Body of a Man standing out of the Chamber, pass through the Air mingled among numberless others that proceeded from circumjacent Objects, and yet, after entering into the Chamber, were separated from all the foreign ones, and collected into the exact Image of the same Man, according to the Laws of *Dioptries*.

If now all these Particles of Light, after so many Mixtures with, or Percussions against, other Particles, can be oblig'd so strictly to obey certain Laws, that when received upon a white Paper, and regularly collected, they will paint and express the just Form of that Person from whom they proceed; what Impossibility is there, that the Parts of a putrified Body, tho' mingled and dispersed among an infinite Number of others, should be brought together again, and compose the same Body, any more than that the Particles of Light do the Figure of it?

If this be not sufficient, our Reader may recollect what has been said in the two preceding Contemplations, *viz.* that not only the smallest *Animalcula*, or Particles of Bodies, cannot escape the Direction of the Glorious Maker and Ruler of all Things; but also, and chiefly, that before all greater Bodies do become Instruments of his Power, he has thought fit, for the displaying of his own Glory, that they should be first divided and separated into Particles of the extremest Smallness, and such as can be scarce conceived by Men. If then it be proved by undeniable Experiments, that there is a Power which has framed all Things upon the Earth round about us, yea, even the great and glorious Body of the Sun itself, of such small Particles, and has disposed them in so wonderful an Order; how can the most unhappy Sceptic, or Doubter of the Resurrection, pretend with Reason to deduce any Argument from the unconceivable Smallness of the Particles into which a human Body after Death may be dissolved by Corruption or otherwise, against the Possibility of the Resurrection of such a Body?

SECT. VI. *The Third Objection, from the Attrition of the Particles, answer'd.*

BUT as the Fancies of some, who wish that all their Notions may be true, are rich in finding out plausible Arguments in favour thereof; so they endeavour to amuse themselves with the Opinions of some famous Philosophers,

phers, who maintain that every thing, especially the smallest, and consequently the weakest Particles, wear away with Motion ; and therefore change both their Figure and Properties, so that after a great many Years, and the passing away of Ages, we do in vain seek throughout the whole Universe for those Parts of which a Body was compos'd, and of which, if they were to be found, it might be again compos'd after the same manner.

But he who contemplates the Operations and Laws that have already obtained in the World, will be convinced ;

First, That by the Art and Invention of Men, whereby they apply the Laws of Nature to their own Purposes, even the whole Frame of the Bodies of Men and Beasts may be preserved unchanged and uncorrupted ; it is therefore much more possible, and likely too, that incomparably smaller Particles may by an unconceivably greater Wisdom and Power be continued in their present State and Condition. Now that the aforesaid is true, will appear from the known Manner, after which so many exotic Plants and Animals are secured from Corruption in Spirits of Wine, refin'd from all their Water, with the Addition of a little Camphire ; as likewise from the embalming of dead Bodies, as well by the Ancients, as particularly by the Moderns, who can much better secure Bodies from Putrefaction. So likewise *Simon de Vries*, in his Description of *Old Greenland*, says, that the Air is so sharp, as to preserve dead Bodies from Corruption ; and the famous Geographer *Sanfon* relates, that when a *Spanish* Colonel marched from *Peyu* to *Chili*, over a high Mountain, some of his People were frozen to Death ; and that several Years after, he found them in the same Condition, that is to say, sitting upon their dead Horses, and holding their Bridles fast, their Bodies remaining uncorrupted.

Secondly, That all Things do not wear away and change their Figures indifferently, has been already shewn in the XXVIth *Contemplation*, *Seet. V.* since if it were so, Water, Air, and the whole World in all its Parts, would be changed as to their Nature and Properties, just contrary to what Experience teaches us.

And if any one desires to be convinced thereof, by an Experiment, which I had made with another View, in order to shew, that the temperating of Acids (as it is called in the Language of the Physicians) does not consist so much according to some, in the obtunding or blunting the acute Parts of the Acids themselves, as in their strict Union with Alkali's, either Watry or other Parts ; let him first dissolve Silver in the Acid Spirit of Salt-Petre, or otherwise in *Aquafortis*, and then after having put a little Water to it, lay a Plate of Copper in the said Liquor, whereupon the Acid will let the Silver go, and dissolve the Copper. But if you throw in some Iron, the Copper is precipitated, and the Iron dissolved by the Spirit, which being filtrated again by the Addition of some *Lapis Calaminaris*, the *Aquafortis* quits the former, and dissolves the said Stone. If then you should pour off this Liquor from all that has subsided in it by Filtration, and then put some Lixivate Salt of Tartar to it, this last will be dissolved and precipitated, and the Salt be united with this *Menstruum* ; so that this Mixture being

Chry-

Chryſtalliz'd, (which is a Sign that the Parts of the Nitrous Spirit remain unchanged) will yield a burning Salt-Petre.

And to ſhew farther, that it preserves its Acidity, I put freſh Water and Oil of Vitriol to the aforeſaid Salt-Petre; from whence, by Diſtillation, I produced again the ſame *Aquaſortis*, or Spirit of Nitre, which, upon trial, diſcovered its Acid Qualities; for when we threw into it ſome unruſted Filings of Iron, I obſerved the Iron to be diſſolved with a great and violent Efferveſcency, and a very red Vapour to aſcend, which is peculiar to a Nitrous Spirit. This was yet more ſtrongly confirmed, by putting ſome Salt of Tartar to it again, by which means there reſulted the ſecond Time a good Salt-Petre from the ſaid Spirit. From which Experiments it does appear at leaſt, that this Nitrous Spirit, after ſo many and ſuch different Unions with Silver, Copper, Iron, Calamine-ſtone, and Salt of Tartar, and after having twice reſiſted ſome of them, ſtill remained in its former Condition, the Particulars thereof being neither changed nor worn by all theſe Motions; which ſhews it is by no means impoſſible, that the ſame Power which preserves to the Spirit of Salt-Petre its Figure and Properties, after ſo many Unions, Mixtures, and Efferveſcences, may likewiſe do as much in the Parts of other Bodies. Thus we alſo ſee Quickſilver and Gold handled numberleſs Ways by the Chymiſts, and yet continue the ſame, after having undergone ſo many Changes.

SECT. VII. *The Fourth Objection, from the Union of theſe Particles with other Bodies, answer'd.*

ANOTHER Objection is wont to be made by ſome, againſt the Poſſibility of a Reſurrección, becauſe, that not only all Bodies are divided into ſuch ſmall Particles by Corruption and other Means, but chiefly becauſe theſe Particles become united, or rather changed into other Bodies; and the Earth, which for Inſtance, proceeds from a Putrify'd Carcaſe of Man or Beaſt, is oftentimes tranſmitted into many kinds of fluid and ſolid Bodies, ſuch as Water, Air, Trees, Plants, and Herbs; ſo that there ſeems to be neceſſary here, not only a bare Union of theſe divided Particles, but likewiſe, *Fiſt*, a Separation from thoſe Bodies wherewith they were united; which to theſe Objectors ſeems incredible, and hardly poſſible in ſo many Millions of Caſes, in which all this would be requiſite towards the raiſing of one only Body again.

But thoſe Gentlemen would eaſily be of another Mind if they were reaſonable, upon our ſhewing them what they look upon as incredible, is brought about many Ways in Chymiſtry, both in reſpect to ſolid, as well as fluid Bodies.

If one put Silver into *Aquaſortis*, it will be diſſolved therein, and turned into a fluid Matter; add a little Copper, and the Silver will be ſeparated and ſink to the Bottom, as we have ſhewn before.

Melt Gold and Silver together, and when they are cold, they will become a hard mixed Metal; but throw that Mixture into *Aquaſortis*, and they will be immediately ſeparated, the Silver incorporating itſelf with that Liquor, and the Gold ſubſiding like a Powder to the Bottom; as is well known to all that deal in thoſe Metals.

The Oil or Salt of Tartar being dissolved in Water, and boyled with Sulphur, will unite itself therewith; but pour a little Vinegar into it, the Salt of Tartar will mix itself with the same, but the Sulphur will be separated.

Mingle Spirit of Sea-Salt with some Volatile Salt, for Instance, with that of Hartshorn, and they will unite themselves closely to each other; but add some Pot-Ash or Chalk thereto, and they will presently quit each other, and the Spirit of Salt will join itself to its new Guest. It would not be difficult for those that are well vers'd in Chymistry, to produce innumerable other Examples of Matters that adhere and unite closely with one another, which yet are easily separated by the Addition of the Third. And if it happens so in these Cases, where is the Impossibility in any other Matters?

SECT. VIII. *The Fifth Objection, That in the Particles of Bodies we cannot observe any such Union, answered.*

BUT it may be, our unbelieving Philosophers will reply, that we cannot observe any such uniting Properties in the Parts of human Bodies, and that therefore there is no such Thing.

But if they would please to attend to other Chymical Experiments, they might see that Water and Oil being put together, will not unite, but remain unmixed; but if you should join the same Oil with Pot-Ash, and Salt of Tartar, or any other good Lixivate Salt, (or even some Oils with Sugar) and make it into Soap, it will easily unite with Water.

Copper is likewise indissoluble, and will hardly be touched by common Water; but if you add thereto some Volatile Salt of Sal-Armoniac, the Copper will be entirely dissolved, and turned into a blue Liquor.

Resin made of Drugs, such as *Jallop*, *Scammony*, &c. cannot be separated in simple Water; but add to them Yolk of Eggs, or pounded Almonds, and they will be easily mixed together; from whence, as also from a great Number of other Experiments which we might borrow from the Chymist, it is plain, that tho' two Matters will not unite, the same may be brought about by the Addition of a Third: And having shewn this in so many Cases, what Impossibility is there again, that the Material Particles of our Body, according to the same, or other Analogous Laws of Plants and Animals wherewith they have been united, may after a Separation be joined again as they were once before?

SECT. IX. *The Sixth Objection, That these Particles are scatter'd too far from each other, answer'd.*

IF any Body that seeks for farther Evasions, should hereupon reply, that these Particles before they can be united to others, must first be brought very near together; but that between those of our Body, there are oftentimes found very great Distances, and that their Union is thereby prevented; let him consider, that tho' Acids and Alkali's must come very near, before they can lay hold on each other, yet Amber, Wax, Glass, will attract Straws, and other light Matters at a much greater Distance, only by being a little rubbed; that the Load Stone draws Iron, tho' it be yet farther off, and that
whatever

whatever is counted heavy upon the Earth, moves, or is attracted towards the Centre thereof; not to repeat here that which must be supposed, according to the Opinion of Sir *Isaac Newton*, and whereof we have given a Proof above in the XXVIth *Contemplation*, viz. that even the heavenly Bodies at their great and almost immeasurable Distances, are subject to a Law that brings them towards each other. If then it appears from hence, that such great Bodies gravitate or move towards each other, according to the present Laws of Nature, tho' at such great Distances, and as far as their Motion will permit, do unite with one another; why should it be impossible for the same Power to do this in human Bodies?

SECT. X. *The Seventh Objection, That the Particles of Matter would act with Choice or Knowledge, answer'd.*

THERE is another Objection, namely, that the Particles of our Body might seem to act with Judgment and Election, if among so many Millions of others they should just meet at the same Places of the Body to which they belong, and concur with them in forming a new Structure.

Yet this is no greater a Wonder, than that among so many other Places where the Particles of the Earth, Water, Light, and Air, might fix themselves, those that are proper to produce Grapes, do only unite themselves to Vines; those of Apples, to Apple-Trees; such as belong to wholesome or unwholesome Plants, are united after the same manner; and notwithstanding that the most poisonous Herbs grow near, or in the midst of a great Quantity of Corn, this last will not be affected thereby.

The like may be observed even in our own Bodies, where from a mixed Chyle consisting of so many Kinds of Meats and Drinks, those Particles are only join'd to each Part of the Body where they are wanting for the support of the same; by which Direction it comes to pass, that Flesh, Bone, Membranes, &c. do all remain unmingled, and in order; without which they would otherwise be soon incapable of discharging their Functions.

And to give other Instances, of which we may find a great many in Chymistry; mix Iron, Lead, Salt, and Stone, all of 'em reduced to a Powder, together; then hold a Load-Stone near it, it will draw the Iron only, and as it were by free Choice out of this Composition, leaving all the rest of the Bodies untouched: Pour Quicksilver upon this Powder, it will only embrace and unite itself to the Lead, neglecting the rest; put some Water to it, that will only imbibe the Salt, and let all the rest alone. The Doctrine of the *Menstrua*, or dissolving Liquors, will furnish us with a great Number of other Instances, wherein each acts upon its proper Object, as it were by free Choice and Knowledge.

Now there is not more required to the Renovation of our Bodies from their Atoms or Particles, than what we see in these Matters.

SECT. XI. *The Eighth Objection, Concerning Canibals or Men-eaters, answer'd.*

BUT the Histories which we read of Men-eaters, seem to be of some Weight with those who would insinuate this Notion of the Impossibility of

the Resurrection into the Minds of weak Men: Since when one Man is devoured by another, the Consequence would seem to be, that as one is turned into the Food of the other, his Body would likewise be changed into the Body of the other; and forasmuch as it is an Article of the Christian Faith, that each one shall rise with his own Body, they think they can prove it to be impossible in this Case; because, tho' the Body of the *Canibal* should be raised in all its Parts, yet that of him who was devoured, will be deprived of several.

Now to remove this Difficulty; these Objectors must be forced to own, that two Cases may come to pass therein. The *First* is, when the *Canibal* lives some Years after the Person he has devoured; for in this Case it is clear, that the Objection will fall to the Ground, because, according to the common working of Nature observable in all Bodies, that which now tends to Food, and to compose a part of the Body, may be separated therefrom long before its Death; for if in the Body of any one who daily makes use of Food, the Substance did not lessen; and if only one Ounce of that Food which a Man takes each Day at every Meal, should be converted into the Substance of his Body, there would be added every Year 20 Pounds to the Weight thereof, and consequently in 53 Years, it will amount to above 1000 Weight; whereas we find it otherwise by Experience. From whence we may conclude, that as the Body becomes heavier and bigger by Food, it does at the same time grow lighter and less by Perspiration, and other Motions of the Fluids, as *Sanctorius* has first observed.

If now we suppose the *Second Case*, and in order to make all the Concessions that are reasonable, allow that this *Canibal*, or Man-eater, does die at such a time as the Objector himself thinks fit; and that the Flesh of the Person devoured is united to the Body of him that eats it: This Objection may seem at first Sight to those that have not much contemplated the Manner of God's working in Nature, to carry some Force with it.

But let these Objectors consider, that altho' the Maker of a human Body permits so many Things to come to pass therein with our Knowledge, and at the Command of our Will, yet he excepts the Nourishment of the Body out of it, that being performed not only without any Power of the Will, but even without our Perception or Knowledge; since after that the Food has passed thro' the Stomach and Bowels (where indeed sometimes we have some Perception thereof) no Body knows what becomes of it afterwards, nor with what Parts, nor at what Time it is united; shewing thereby, that this Benefit which is procured to us by the taking of Food, depends perfectly and only upon his Will. We see likewise that some sickly Dispositions, as also too great Heat, too violent a Motion, too great a Passion, which last are not wont wholly to deprive us of Health like bodily Distempers, are oftentimes the occasion that our Bodies are not nourished by the Food that is used, so well as at other times.

From whence it is probable, that if the Design of the Great Creator of all Things be that every Man should Rise with his own Body, as He has declared to us in his holy Word; 'tis likewise in his Power to hinder, that no one

Particle should essentially belong to two Bodies, and that, even after a natural Manner, there is no Impossibility in it.

But if this Argument should not appear sufficiently convincing to some, they may be assured thereof by numberless Chymical Experiments; by which it will appear, that tho' a Body has the Property of uniting itself to another, yet it can be hinder'd by the Addition of a third, and by other Ways too from doing the same.

Thus Spirit of Salt-Petre will unite with Steel; but if one first puts into it a fixed Alcaline Salt, such as that of Tartar, the aforesaid Effect will be prevented.

A Lixivate Salt will mix with Oil, and turn it into Soap; but put a little Vinegar to it, or any other Acid first, and the Salt will not incorporate with the Oil; and even when the Mixture is actually made, they will be divided and separated thereby.

Iron will join itself to the Load-Stone, or rather they will move towards each other; but turn them only the wrong way, and they will fly from, or drive one another away. But to Instance in no more Cases, as one might easily do from Chymistry, who can give any Reason why the same Power that does all these Things, cannot bring about the same Effects in the Parts of a Man, whose Body has been united as Food to the Body of a Canibal?

SECT. XII. *Conviction and Possibility of a Resurrection.*

I KNOW very well, that some ingenious and acute Philosophers may not be at a loss to fancy Hypotheses, in order to solve the Causes of all those Experiments we have produced, and it may be such as may seem to have some Analogy therewith; and that even all the Chymical Phænomena are accounted for, by one this way, by another, that; but it is not necessary either to admit or to reject the whole: *First*, because we do not here undertake to inquire into the Truth of those Principles upon which each Man builds his System of natural Knowledge. *Secondly*, Because it is sufficient to our Purpose, if the Experiments be only true, let People deduce them from such Causes as they shall judge most consistent with their own Hypothesis: Forasmuch as no Body can pretend to prove from such Pores, such a Figure, such a Determination of Motion, such an attractive Force in the Parts of Matter (from which Principles most Causes are derived in this Age) whether it be possible that each of these are likewise to be found in others; and that the same Power which has adapted the first to these Properties, does likewise do the same in others, by changing them every time according as it shall judge it to be most serviceable to its great Ends and Purposes.

SECT. XIII. *Transition to another kind of Threefold Objections.*

I MIGHT have made an end here of the Proof of the Possibility of the Resurrection in the same proper Bodies, were it not that some Atheists pretend to defeat the same after other Manners; namely, *First*, by unadmittable Consequences, which they think they can draw from thence. *Secondly*, By the Supposition of Things that are possible, which notwithstanding the Resurrection

edion of the same Bodies, makes impossible according to their Notions. *Thirdly*, By comparing the Bible with itself (from whence all Christians prove the Certainty of their Resurrection) and by quoting such Texts out of it, which, as they would make us believe, seem to have very little Agreement with a Resurrection in the same Body. And I hope we shall not appear tedious to the Learned, if we still add something here to obviate these Difficulties, especially if we use no other Proofs therein, than such as are founded upon daily Experiments.

SECT. XIV. *Three Objections of the first Kind.*

THE First Consequence then, which they think must appear absurd and unadmittable to every one, is, That in case the Resurrection be made in the *same proper* Body, a Child dying soon after its Birth, will rise again likewise as a Child, and with an imperfect Body.

The *Second* is, That if any one whilst he is yet a Child, loses a Leg or an Arm, and lives afterwards some Years, and grows bigger, he must believe that when he dies, he shall rise again maim'd, and without Arm or Leg; or in case his Body be supply'd with those Limbs that are wanting, they will be wholly disproportional to the rest.

The *Third* is, That if a Man is to rise with his *own* Body, it seems to them a necessary Consequence, that almost all Bodies will be entirely spent and wasted, and much smaller and lighter than they ought to be naturally at the Resurrection: Since most Men before they die, fall away so much through Sicknes, and some are so exceedingly wasted by Consumptions, as to fall far short of that Weight and Size which belong to their Bodies in Health.

SECT. XV. *Objections of the second Kind.*

THE Fourth Thing which they Object, and which, tho' possible in itself, they think the Belief of Christians renders impossible, is the following: If a Canibal or Man-eater should live a Number of Years, and in all that time should use no other Food than human Flesh, it seems impossible to them that both the Canibal himself, and at the same time all that have been devoured by him, can rise again with their own perfect and proper Bodies.

SECT. XVI. *Objections of the third Sort from the Holy Scriptures.*

THE Objections which they themselves produce from the Holy Scriptures, are first, such Texts where express mention is made of a Resurrection in the same Body; as *Job* xix. ver. 26, and 27. *Tho' after my Skin Worms destroy this Body, yet in my Flesh shall I see God, whom I shall see for my self, and mine Eyes shall behold, and not another.* And *Paul*, *Rom.* viij. ver. 11. *He that raised up Christ from the Dead, shall also quicken your mortal Bodies;* as also *Phil.* iij. ver. 21. *Who shall change our vile Body, that it may be fashioned like unto his glorious Body.* We shall not repeat all the rest that are of the same Tenor.

Against these Texts they oppose some Expressions of the said Apostle, 1 Cor. xv. ver. 35, 36, 37, 38. which they think cannot be understood consistent with the former; for when before, he introduced an Objector using these Words, ver. 35. *But some Men will say, how are the Dead raised up? And with what Body do they come?* He answered the same by a Comparison of a Grain of Corn, ver. 36. *Thou Fool, that which thou sowest, is not quickened except it die;* ver. 37. *And that which thou sowest, thou sowest not that Body that shall be, but bare Grain, it may chance of Wheat, or some other Grain,* ver. 38. *But God giveth it a Body as it hath pleased him, and to every Seed his own Body.* From which Works therefore they conclude, that we shall not assume at the Resurrection the same Bodies which are put off at Death; but that they will be other, and different, and such as God gives according to his Pleasure. So that according to them, this Text seems to contradict the former, and likewise itself, because if a Man sows any Thing else than the Body that shall be, and that God gives to the thing sown, *a Body as it hath pleased him,* 'tis impossible in their Opinion to be the same Body of that Seed.

Besides this, some of 'em urge other Difficulties against a *Spiritual Body*, ver. 44, and 46. and especially because in ver. 50, it is said, *that Flesh and Blood cannot inherit the Kingdom of God.* This seems to them contradictory to the former Passages quoted from *Job*.

SECT. XVII. *Our Design here is not to describe the Manner of the Resurrection, which we must leave to God.*

BEFORE I pass on to answer these Difficulties, I find myself obliged, for the Instruction of such Christians as may happen to read this, to premise:

I. That our View here is not to account for the Manner of the Resurrection of the same Body, which great Mystery we must leave to the Wisdom and Power of God only; nor have we undertaken any Thing more, than to shew that such a Resurrection involves no Impossibility in it; and that the foregoing Objections raised by some Atheists, even from the Holy Scriptures, in order to sooth and quiet their own Consciences against the Terrors of this Resurrection, may be easily cleared up and removed, from what we find daily passing in the World by our own Experience.

SECT. XVIII. *A General Answer to all the Objections against a Resurrection, taken out of Scripture.*

II. To return a general Answer to all that these unhappy Cavillers, and deplorable Biblereaders (I mean such as only sift the Scriptures to discover Absurdities therein, as I have known some such) fancy they have found in that Holy World, which they can neither reconcile with their own Notion, nor with other Texts that treat of this Resurrection. I say, nothing more is required to answer these People, than what we find to be expressly affirmed in the said Scriptures; namely, that in order to understand the true How, and other Circumstances of the Resurrection, we must, according to the

the before quoted Reply of our Lord to the *Saducees*, not only *know* the *Scriptures*, but likewise the *Power of God*, if we would not *Err*.

SECT. XIX. *A bare Hypothesis is sufficient to shew the Possibility of any Thing.*

To disarm the Atheist as much as possible of all their Evasions, it is necessary to add, that tho' what we should hereafter produce from natural Observations, could not be demonstrated to be strictly true, but were only a simple and naked Hypothesis, it would carry with it perfectly the same Weight and Force in this Matter. Since to prove the Possibility of any Thing, there ought not to be more required from him that asserts it, than only to find out an Hypothesis containing the Manner how it may come to pass, and which includes no Contradiction in it. I don't think that any Atheist will deny this, since it is own'd by the chiefest of their Sect. To begin then :

SECT. XX. *There is a Proper or Own, and a Visible Body.*

I. EVERY Man has besides his Soul, a *Body*, which, for so far as it can be seen by all, we shall express by the Name of a *visible* Body.

II. This Body may be termed, in respect to those of other Men, one's *peculiar* or *particular* Body, since a Man is thereby distinguish'd from others, and it is the Composition of this particular Person, and no other.

III. But since this *visible* and *particular* Body does undergo very many Changes, and according to the Difference of Years, and to the good or bad Constitution of a Man, and otherwise, becomes smaller and greater, leaner and fatter, lighter and heavier ; and that it is even possible that one and the same Matter may now belong to the visible Body of one Man, and afterwards to that of another ; as for Instance, if the Blood of one Man, by a Wound or otherwise, should be spilt upon the Earth, the Matter of it might serve to feed some Plant or Fruit, which being afterwards eaten by another, contributes to the Increase of his *visible* Body : And since, notwithstanding all these Changes, every *visible* Body does still remain the Body of the same Person, it is apparent that there must be something in the *visible* Body which undergoes so many Changes, from whence it has a Right to be always denominated the *own* Body of the same Person ; of which Term we shall likewise make use in the following Discourse, in order to make a Distinction between the *own* and *visible* Body of every Person.

IV. And thus it is plain, from what has been said, that there is an essential Difference between the *own* and *visible* Body of a Person ; since many Parts of the last can be joined to, and separated from it, and even belong to more visible Bodies than one ; but the *own* Body remains fix'd and determined to one and the same Person only.

SECT. XXI. *This Distinction is acknowledged by all.*

V. AND that none may think that this Distinction between a *visible* and an *own* Body is invented by us, and has no Foundation in Truth ; it is known that if one says of a Man, *that he weighs* 200 lb. nothing else is understood

derstood thereby, than that it is his *visible* Body which is of that Weight ; but if one says, *that such a Man is 80 Years old*, it can only be meant of the *own* Body, since all the Food that he has used in the last 10, 20, or 30 Years of his Life cannot be said to have appertained to his *visible* Body the whole Space of 80 Years.

SECT. XXII. *The visible Body consists of Fluid and of Solid Parts, and of Laws.*

VI. Now to enquire wherein this *own* and *visible* Body does determinately consist, it must be confess'd, first, that this *own* Body which helps to compose the Person, is not the *visible* Body wholly and solely ; [See Numb. IV.] it must therefore be contained within the *visible* Body.

VII. This *visible* Body consists,

First, Of *Fluid Substances*, as Blood, Whey, *Lympha*, Chyle, and Milk in Women that give suck, and Water in which the Embryo lies in those that are pregnant ; various Kinds of Glandular Juices from the *Pancreas*, the Glands of the Stomach and Intestines, Gall, Spittle, Sweat, and perspiring Matter, Tears, Snot, Nervous Juice, and others, that have yet no particular Name ; to which some add Fat, the bitter Matter in the Ears, that in the Seminal Vessels, and the like, tho' they are something thicker than Liquors or Fluids.

Secondly, Of *Solid Matters*, Flesh, Bones, Nerves, Membranes, the Teeth, &c. The modern Inquirers reduce them all to Bones and Nerves, as we have observed already in *Contemplation XI. Sect. 17.*

Thirdly, Each *visible* Body, whilst it is alive, has its particular Laws ; thus there are Laws in human Bodies, according to which are regulated the Consumption or Digestion of the Food in the Stomach, the Separation of the Chyle from the grosser or excrementitious Matters, the Sanguification or Conversion into Blood, the Separation of the Humours, the Motion and Nutrition whereby the said Blood is turned here into Bones, there into Nerves and Tendons, in another Place into Membranes, &c. besides Generation and Production. According to these Laws, we see, that when a Piece of Bread is eaten by a Man, a Dog, a Fowl, and a Carp ; in the three first it is turned into different kind of Flesh, in the last it becomes Fish ; and the same Food makes a white Skin in an *European*, and a black one in a *Moor*, as it makes one Man fat and another Man lean ; and we find that Children using the same Food, are subject to the same Laws ; that the Stomach of one digests with Ease and Pleasure, one kind of Food, as the Stomach of others does another.

SECT. XXIII. *The own Body consists, in a manner, of no Fluid Parts, nor of Laws, but almost only of solid Parts.*

VIII. So then the *own* Body of a Man must consist of one or more of these three, *Fluids*, *Solids*, and *Laws*.

It does not seem to consist of the *Fluids*, since many of them are changed, become more or less, and may be intirely separated from the Body, whilst

at the same Time it shall remain the proper and *own* Body of the same Person : Thus the Blood daily diminishes by the Separation of Humours, and by Perspiration, and is as daily increased by a new Chyle ; not to mention great Effusions of Blood both in Men and Women ; of the last of whom, I knew one who in a few Years had lost much more Blood than the Weight of her whole Body was equal to ; now whether it was a Blood consisting of this or that Matter that flowed thro' her Veins, her Body remained unquestionably the same proper Body.

Now since the Blood does not belong essentially to the *proper* Body, neither can all the Humours that are separated from it, be counted to belong to the same, forasmuch as they are daily changed ; thus Fat is diminished by Leanness, and other Fluids by other Means, from thence we may conclude, that hardly any, at least very little, of the Fluids, are necessary to the Composition of what we call the *own* Body.

IX. Now that the Laws likewise do not belong essentially to the *own* Body, is apparent ; *First*, Because the same are frequently changed in the same Men, whilst they remain in the same Persons. Thus Experience teaches us, that sick and healthy People, young and old, are not subject to the same Laws, which holds true both in Men and Women. *Secondly*, The same may be inferr'd not only because the Body is material, and the Laws do only consist in certain Motions and Properties, but particularly (which puts the thing past all doubt) because a dead *visible* Body, in which it cannot be said that these Laws do any longer prevail, is as much esteemed to comprehend the *own* Body of the deceased Person, as when it was living.

X. Lastly, Since it plainly appears, from all that has been said, that a Body may still continue the *own* proper Body of the Person, tho' filled with Humours and Juices quite different from those it once had, and that such Fluids may be likewise moved by quite different Laws, but even those Laws may also entirely cease when the Body is dead ; we must therefore only seek for this proper *own* Body in the simple and naked *solid* Parts thereof.

SECT. XXIV. *The own Body consists either of a Stamen or Principle unfolded only ; or else of a Stamen, that grows and increases by the Addition of Foreign Particles.*

VIII. Now to treat more closely of these *solid* Parts.

It is very well known to those that are versed in the Inquiries of the present Age, that as the Plants and Animals, so likewise Man does consist of a first Principle or *Stamen*, which may therefore be denominated the *own* Body, or at least something that contains the same ; as has been already shewn in the XVIth *Contemplation*.

The Parts of this *Stamen* are in the Growth of it, and from time to time expanded, or unfolded, and cloathed as it were, and filled up with other Particles continually, till the visible Body of a bigger, and at least of a full grown Creature, results from it.

Now since this *Stamen*, during the Growth of a Body, is clad and stuffed with other Matter in and about it, and since it contains all the solid Parts of the Body in Proportion to its Bigness, either this simple expanded *Stamen*, without any other adventitious Matter, must be admitted and allowed to be the *own* Body, or else the same *Stamen* filled and cloathed with that Matter, which afterwards become Bones, Flesh, Ligaments, Membranes, &c. so far as those compose the solid Parts of a Body, must be reckon'd the *own* Body; one of these is certainly true.

We shall therefore, in both these Cases, one of which must needs be admitted, endeavour to solve the Objections of Atheists; and first, those which they are used to bring from Nature, and next from the Holy Scriptures.

SECT. XXV. *How a Man may be said to rise again with his own proper Body, in the first Case.*

IX. IF it be supposed that the bare *Stamen*, expanded according to the Bigness of the Body, without the Accession of any other Matter to fill and cloath the same, be the *own* Body, and which is to continue so in all Men from their Birth to their Death; there will be nothing more required, that such a Person should rise with his *own* Body, than that only this *Stamen*, separately from the Particles that cloath and fill the Body, should remain, and be continued in its own little Substance, and that the great Author of our Resurrection should, after Death, unfold, fill, and cloath the same into a visible Body, with the same Matter that belonged to it before, and in its Life-time, when it was a visible Body; or else with such other Matter as he shall be pleased to use. We shall not speak of the altered or changed Properties and Faculties, since they do not affect the Matter thereof, nor do change the *own* Body as to its Essence; but refer it to the Word of GOD, touching the same.

SECT. XXVI. *The own Body, tho' filled with other Matters, remains the own proper Body of the same Person.*

X. BEFORE we proceed any farther, let me add two Things that may obviate all Objections against what has been lately said.

First, That an *own* Body, tho' filled and cloathed into a *visible* Body with other Matter that never belonged to it, does nevertheless remain the *own proper* Body of the same Person; nor does this want much Proof, since any one that has fallen away by Sicknefs or Pain, if after his Recovery he becomes bigger and fatter, and for that Purpose has used Food that was never any part of his own Body, will always be reckon'd to have been the same Person, and consequently to have been alter'd by becoming so much more *visibly* bigger and fatter.

SECT. XXVII. *When any one dies, a great deal of that Matter which belonged to the visible Body, will be separated therefrom.*

XI. *Secondly*, THAT when a Man has lived some Years, a great Quantity of that Matter which belonged to his *visible* Body, may be separated from it, and he still remain the same Person; insomuch that the *own* Body undergoes no Change by the Loss or Accession of such Matter that help'd to make it a *visible* Body.

To prove this; Let us again suppose a Man that is 80 Years old, and that weighs 160 Pounds, and who, reckoning one Day with another, after Breakfast, Dinner, and Supper, unites but one Ounce every Day of the Food he uses to the fluid and solid Parts of his Body, in order to repair what he loses by Perspiration, and other Ways; according to which, without reckoning the Weight of his whole Body as soon as he was born, there would be 80 times 365, which is 29,200 Ounces, or 1825 Pounds of nutritious Matter, that has gone towards the Composition of his *visible* Body in the Space of 80 Years; from which if we subtract those 160 Pounds, there will still remain 1665 Pounds, which during his Life-time, when they were at first nothing but Wheat, Rye, Fish, Flesh, &c. did not belong to his Body, but were quite foreign to it, and might as well have gone towards the Composition of any other Man's *visible* Body, as of his; and which afterwards have served to nourish his *visible* Body for some Time, and finally have been separated again from it; in all which Cases none can deny that it has been the same Person, and therefore always preserved his own Body, from which, what has been said before is sufficiently demonstrated.

SECT. XXVIII. *The three Objections of Sect. XIV. answer'd, in case the own Body consists of a bare Stamen.*

XII. Now to return a particular Answer to the particular Objections started by the Atheists, *Sect. XIV.* and *XV.* and which they pretend to raise from Nature, upon this Foundation, that the bare *Stamen* does only remain the *own* Body, and is only expanded or unfolded from itself into a larger Size, by extending the Parts of it farther from each other (of which an Example may be seen in the *XVIIth Contemplation*) there is no need of any other Argument than the following:

If a Child were to rise again as a Child in its *own* Body, the Matter of its *Stamen* need only be preserved, and be again filled up at the Resurrection by other or by the same Particles by which it had been increased before.

If a Person is to be raised as full grown, the aforesaid *Stamen* needs only to be expanded after the same manner as it would have been in the Life-time, and then filled up and clothed with Matter, which, when it remained alive, and increased in Bulk, would have served for filling up the same; in which Case, every one must acknowledge, that the same Person would have risen again in his *own proper* Body.

The same may likewise be said, if any one that is now a Man, and had lost a Leg or an Arm in his Childhood, should die; for here it is only requisite, that that Part of the *Stamen* which was to compose the Arm or Leg, should be expanded, filled up, and cloathed, in Proportion to the bigger Body, as has been shewn before concerning the smaller.

Moreover, if any one dies lean and wasted, and at the *Resurrection* his Body is filled with Matter, which did either never belong to him, or otherwise, with such as had before filled up his own to a *visible* Body, why should he, at the *Resurrection*, be less accounted the same Person, and be reckoned less to enjoy his own Body, than *Job* is said to remain the same *Job*, and to have retained his own Body, as well, when by the Goodness of God he was restored to his former Strength and Health, as when he was so wasted, as to be able to say of himself, *Chap. xix. ver. 20. My Bone cleaveth to my Skin and to my Flesh, and I am escaped with the Skin of my Teeth?* Now it is very probable, that that which render'd his *visible* Body bigger and heavier after his Recovery, consisted of such Food and Matter as did not before belong to the same.

SECT. XXIX. *The Objection in Sect. XV. answer'd upon the same Foundation.*

XIII. FINALLY, if now even a *Canibal* had, during his whole Life, fed upon nothing but the Matter of the *visible* Bodies of Men, and it had only pleased God to hinder that the *Stamina* of all those whom he had devoured should have been converted into Food, but that they should have passed thro' his Body with other excrementitious Matter; what Impossibility is there, that the particular *Stamen* of each Person (which we here suppose to be the own proper Body) should be separated from thence, and filled up again by other proper Matter, or, it may be, by some that had served the same Purposes before, as well as other dead Bodies. For it has been already shewn, in *Numb. XIV.* that when a Person dies after some Years, there are always a great Number of Particles separated from his Body, at the Time of Death, which had served before to the filling up of a *visible* Body.

Thus likewise may the *Stamen* of the *Canibal* himself remain alone, without any of its expanding Fluids, and be filled up with others at the *Resurrection*, and he accordingly may rise likewise in his own Body. For who can deny that any Man, for Instance, that has lived twenty Years upon human Flesh, and after that, fifty Years more upon Bread, does not, in both these Cases, retain his own Body? For which Reason the proper Body of any Person does remain the same proper and own Body, tho' fill'd up with other Fluids. See Sect. XXVI.

SECT. XXX. *The visible Body of a Man may be very much emaciated, and yet remain his visible and own Body.*

XIV. Now to pass on to the second Thing mention'd in Sect. XXIV. and to solve the Objections of the Atheists by this other Principle, that the own Body of a Man does not only consist of the simple *Stamen*, but does
moreover

moreover always comprehend some of the filling and cloathing Matters which adhere to the said *Stamen*, altho' what has been already mention'd be sufficient to demonstrate the Possibility of a Resurrection in the *own Body*, against all Atheistical Evasions whatsoever.

Let me here premise, that it is experimentally known to many, that the *visible Body* of a Man may be extreemly emaciated, or become very lean, and yet remain his *own*, and likewise his *visible Body*. Accordingly two Instances, among many others, do particularly recur to my Mind; the first was of a Person who had before been very Musculous and Flethy, but was, without any visible Fever, so exceedingly reduc'd by a *Marasmus* or *Leanness*, that his Legs and Arms, and all his Body besides, appear'd to them that saw and felt him, to be nothing but Bones, or a living Skeleton; his Skin was all over blackish, and very hard, cleaving almost inseparably to the Bones; nor could we externally discover the least Softness of any Muscles, of which, notwithstanding, the solid Parts remained under the Skin.

The Second, who was likewise before a very corpulent and fat Man, upon the bursting of three Vessels in the Lungs, call'd by the Anatomists *Vomica Pulmonum* (from the least of which there proceeded by coughing and reaching as much Matter as would fill half a common Bason, and from the biggest much more, in less than an Hour's time) was in a little while reduced to such a Leanness, that his Flesh was quite wasted; and the same was attended likewise with a continual Cough, which lasted even a great while after he was asleep. Notwithstanding which, both these Persons afterwards recovered their Health to such a Degree, that the first of 'em was again plump and fleshy, and the other grew extreemly fat. I have related both these Histories, because no Body ever question'd, nor can it at all be doubted, that these Men, in both these so different Cases, were the same Persons, and that their fat as well as their lean Bodies might and ought to be denominated their *visible* and *own Bodies*.

SECT. XXXI. *The own Body, tho' allowed to be a Stamen, with an Accretion of foreign Matter, consists of nothing else but of solid Particles, and chiefly of Bones.*

XV. BEFORE we proceed, it must be here again observ'd, that the *own Body* of a Man, tho' consisting of a *Stamen*, increased with other Matters, is, as has been already hinted, only composed of *Solid Parts*; forasmuch as the *Fluids* and the *Laws* are daily changed, and the last of 'em do entirely cease at the Time of our Death.

Moreover, since a visible Body, tho' reduced to such a Leanness as we have just now shewn, may continue to be the *visible Body*, having never been entirely deprived of its Fluids during its Leanness, the *own Body* must be still less in Matter than the emaciated visible Body.

Finally, that this *own Body* does consequently consist of nothing else but Bones and Nerves, of which likewise the Membranes, and of them the Tubes of the Flesh are composed, (*See Contemplation XI. Sect. XVII.*) and the said Flesh, when the Blood and Humours are separated from it, is so very small a Part of the *visible Body*, that it can hardly be seen, nor even felt externally in the

the greatest Leanness; so that from hence it appears, that the real *own* Body does chiefly consist of mere Bones.

SECT. XXXII. *The Three Objections mentioned in Sect. XIV. solved, upon the Supposition, that the own Body does consist of a Stamen increased to a certain Bigness.*

XVI. Now in order to solve the former Objections likewise from this Second Principle, of which mention has been made in *Sect. XXIV.* Suppose a Child to die, if it be to be raised again as a Child, it is unquestionable that it puts off by Death its *own* Body in the *visible* one.

If it be to rise as a full grown Person, it is certain that no Atheist can deny, but that this *own* Body of the Child would have been filled up and cloathed with other Matter that never belonged to the same, if the Child had lived to Man's Estate, and yet it would have remain'd the *own* Body of this Person. Now in case the Body of such a Child should at its Resurrection be increased with the same Matter, which would have been made use of if it had remain'd living; what Reason can there be to affirm, that such a grown Body would not have been the Child's *own* Body in the one Case as much as in the other?

The same Thing may likewise be apply'd to a Person, that in his Youth has lost a Leg, or an Arm, or any other Member; as likewise to those Objections, that most Men must rise again with meagre and wasted Bodies. Forasmuch as we have shewn above, *Sect. XXX.* that not only a Body almost utterly emaciated, but also in the Case of *Job*, the same Body fill'd with other Fluids (such as never belonged to it before) may remain the *visible* Body of the same Person; and no Reason can be given, why that which happens at the Resurrection to a Body emaciated by Sickness, may not likewise be apply'd to a Body fill'd with Parts that render it much more beautiful, and denominate it the *own* and *visible* Body of the same Person; the rather, since such a Repletion or Increase may likewise be made with such Matter, which even had served before to the filling up of the same Body in its Life-time; of which, at the Resurrection, there will be at hand a great Quantity, and more than is necessary. See *Sect. XXVII.*

SECT. XXXIII. *The Objections of Sect. XV. answer'd from the said Principles.*

XVII. FINALLY, to return an Answer to the Difficulty which these deplorable Philosophers think impossible to be solv'd, and which they fetch from the Example of a *Canibal*, who was supposed to have devour'd a great many Men, and to have used no other Food: These Gentlemen are desired to observe in the first Place, that the Foundation of their Mistake consists herein, *viz.* That the Body of such a Man-eater can be nourish'd as well by the *own* as *visible* Body of one or more Persons, the contrary whereof is true.

To prove this, can a *Canibal* support his Life (not to speak of his Health) wherewith, if nothing but such emaciated Bodies, as we have described above,
were

were allowed him for Food? Can he likewise eat Bones that are withered to a greater Degree even than those that are dried in the Sun? Can he be nourished with Nerves and Membranes entirely and perfectly divested of all their Juices? For a *visible* Body, though never so much emaciated, can yet be in no Sense esteemed an *own* Body, as long as there are any Fluids therein, as we have shewn above, *Seet. XXII. and XXIII.*

On the contrary, daily Experience teaches us, that what we make use of for Food does belong only to the *visible* Body of an Animal, and the Fluids that are therein. Thus we know that the Gravy of Roast-Meat, and the Slop of that which is down boiled, yields a very hearty Nourishment, but that the solid Particles belonging to those Bodies upon which we feed, are separated from the Nutricious Juices, and pass off through the Body.

To conclude; Since now the *own* Body must be considered abstractly from any Humours and Juices, and since all that serves for the Food and Nourishment of a Man-eater, must only be divided from the *visible* Body of the Person devoured; it is plain, that altho' a *Canibal* had devoured hundreds of *visible* Bodies of other Men, it would likewise happen, according to the common Course of Nature, that the solid Particles divested of all their Juices, or the *own* Bodies of the devoured Person, would be discharged, or cast out unmingled with those of the Devourer; and consequently that each of them might appear separate and entire at the Time of its *Resurrection*.

SECT. XXXIV. *Convictions from all the foregoing Objections.*

XVIII. Now let an unhappy Atheist ask himself seriously, and in his Retirement, whether all these Objections which he is wont to fetch from Nature, can secure him against the Possibility of a *Resurrection* so much dreaded by him? And if he argues without a Resolution of not believing the same, whether these studied Evasions can free his Mind from the continual Terrors that must unavoidably follow the least Reflections of an approaching Resurrection, and the Considerations of appearing before the Judgment-Seat of that Just and Almighty GOD, whom he has so frequently, and so unworthily blasphemed?



CON-



CONTEMPLATION XXIX.

Of Unknown Things.

SECT. I. *Transition to Unknown Things.*

SINCE we have endeavoured in the foregoing Contemplations, to shew from a very small part of what is known to us both in the great and little World (and we hope likewise with unquestionable Success) that there is such a Being as a Wise, Mighty, and Gracious GOD; we might here put an end to this Work, were it not that even in those Things which are still unknown, and which, perhaps, will remain for ever unknown to all Men, there did not seem to remain some Proofs great and strong enough to bring unhappy Atheists to a better Mind.

SECT. II. *That there are many Things still unknown.*

IT will not be very necessary to use many Arguments to prove, that there are unexpressible Number of Things in the Visible World, as yet unknown to all Men. The different Opinions which prevail among the greatest and most learned Men, about the Causes of the same Appearances, prove this Assertion plain enough; and one might well judge a Man very uncharitable, who when any one among those Learned Men had proved properly and experimentally the Truth of his Opinions, should think of all the rest, that they could be so unreasonable as to refuse to comprehend, or so stupid as not to be able to comprehend this Truth: At least this is certain, that if there be three Persons of different Opinions, two of them, and it may be all three, know nothing of the Matter. And, not to repeat here the Confessions which great and famous Mathematicians have made of their Ignorance of many Things, with a generous Self-Denial (of which one may see one Example in the thirteenth *Hydrostatical Proposition* of Dr. Wallis, and another in the eighteenth *Optical Lecture* of Dr. Barrow, Sect. 13.) let the proudest and most self-conceited Atheist tell us, whether there is any real particular thing, such as the *smallest Leaf of Grass*, or the *most contemptible Insect*, that are perfectly known to him; and concerning which numberless Questions might be proposed to him, whereof he would be scarce able to answer any; at least, could he tell us concerning one of those, or any other material Being, how the smallest and original Particles thereof are formed, how disposed, how moved, and what sort of Pores or Interstices they make with one another? And even, not to go so far, could he with all his Wisdom be able to say, how a thing would appear through a good

H h h h

Micro-

Microscope, unless he had taken the Pains before to examine the same? And after all, since there are so many Things which are quite out of the reach of the nicest Inquiry, one may easily conclude, that in each of them there is a great deal that is wholly unknown to him. But this may suffice here, since I cannot imagine that there is any Body who would pass for wise or reasonable, that will not readily own, *There are many Things of which he is entirely ignorant.*

SECT. III. *Atheistical Objections answered.*

I KNOW very well, that among these unhappy Men there are some, who, to elude the Proofs of a Wise God, (the very Thoughts of which is dreadful to them) endeavour to screen themselves against the Reproaches of their convinced Minds behind these unknown Things, saying, That if there be still so much unknown, how can we extol the Wisdom of a Great Creator, which can only manifest itself in the Things that are known? To answer which, before we proceed any farther, and for the Satisfaction of such as may stumble thereat, we affirm, *First*, That the Wisdom and Skill of an Artificer is not so much displayed by the Number of Things he has made, as by the Contrivance and Workmanship that appears in each of them. For instance, need we desire to see any more than one Watch well made and skilfully put together, to judge of the Knowledge of the Maker? And if we see but one compleat Picture of a Painter, will it not be sufficient to acknowledge him to be a great Master? Now if this be true, as it cannot be contradicted, I leave it even to the Atheist himself, whether he must not own, that in the foregoing Discourses not one, but very many Instances have been produced, of a Wisdom that governs the World; and consequently, altho' there be an infinite Number of Things still unknown, whether those which we now know are not abundantly sufficient to demonstrate the Wisdom of their Maker: The rather, since that in knowing all these Things, we know a great deal in respect of others that have never inquired into, nor read the Discoveries in Natural Philosophy; which, however, is very little, in Comparison of what remains to be still known.

Secondly, These Objectors must be told, that a Man may be entirely ignorant of the Structure of a Machine, and of the Manner how it is put together, and yet not be the less satisfied of the Art and Wisdom of him that framed it; especially when one sees that it is accurately and nicely adapted to perform some great and useful Design. For can any Body observe a good Microscope, consisting of two or three Glasses, so wonderfully contrived for viewing the very smallest Objects; or a noble Telescope, made use of for the clear and distinct contemplating the Heavenly Bodies, so vastly distant from us, and consequently invisible to our naked Eyes; or a fine Clock, shewing the Days, Hours, and Minutes, and endued with several other Motions, and yet persuade himself, that all these were made without any Skill or Contrivance, only because the Structure and Disposition of them are unknown to him?

SECT. IV. *Unknown Things, tho' in themselves not conceivable, do yet prove the Greatness of God.*

IF now it be obvious to every one, that from what has been said about unknown Things, even Reason will teach us that God may be magnified thereby; the Wisdom of his Holy Word, tho' it were not allowed to be Divine, does likewise appear as plain from thence; not only because it does not make use of any Philosophical or Mathematical Demonstrations to prove the Power, Wisdom, and Goodness of God; but particularly, because it makes use of Things that are unknown to Men, and even unscrutable, in order to convince us of the infinite Perfections of God, of the Meanness and Vileness of Man, and to shew the Reasons that we all have to praise Him and admire his Glory.

To give an Instance thereof, Whether we suppose the World and all material Beings in it, to have been produced in the Beginning by the commanding Word of an Adorable Creator, as is confessed by Christians; or whether according to the Hypotheses of unhappy Atheists (for higher than an Hypothesis they cannot pretend to go) it should be admitted, that if not the Form, yet the Matter of the World is Eternal: This at least will unquestionably result from each of those Hypotheses, that all the Particles of which all human Bodies are composed, have existed as long as the World, or as long as all Matter itself.

Now then no Body can deny (because it appears too plain by Experience) that all the Parts of our Bodies did at first exist in the Food that has been made use of for the Growth and Increase thereof, and consequently in Wheat, Rye, Barley, Rice, as also in the Flesh of Oxen, Sheep, all kind of Fowls and Fishes, in the Fruits of all Trees and Plants, and, in one Word, in every thing that serves to support the Life of Man. Consequently that they were likewise to be found in every thing from whence such Plants and Animals have been produced, that is to say, in Earth, Water, and Air; and thus tracing them still backwards, we meet with them in every thing whereof this very Earth, Water, and Air consists, namely of corrupted and putrified, burnt and consumed Bodies. So that if we go back from one thing to another, and follow this Thread to the Beginning of the visible World, must not every one that seriously considers the same, be convinced, that his Body, and all the Parts of which it at present consists, have incessantly passed from one Mixture and Composition to another, for as many Ages as the World has lasted; so that these our Hands and Feet, and all the Limbs we now possess, have, with respect to their original constituent Particles, been dispersed and scattered thro' infinitely different Places for Thousands of Years past, growing in Plants upon the Ground, walking with Cattle in Meadows, flying with Birds in the Air, swimming with Fishes in the Water, and plowed up in the Furrows of the Earth. And since Water and Air likewise do bear a part in the Composition of our Bodies, the Particles thereof which are now mixed with our own Flesh, have been exhaled out of Rivers, have ascended in Vapours, and descended in Rain, Hail, and

Snow, have been kindled in Lightning, and other Meteors, have been scatter'd in Storms, and waisted backwards and forwards to all Parts of the World by the Winds ; and thus in numberless Places, at numberless Times, and after numberless Manners, have undergone numberless Compositions and Mixtures, till they have been finally collected and become the constituent Parts of these our Bodies.

Now tho' nothing of all this implies any Infinity, or any Incomprehensibility ; yet the most self-conceited Atheist must acknowledge, that neither he, nor any else can ever be able to trace this his Genealogy or Pedigree ; nor to say in what Figure, in what Structure, or in what Places the Parts of his present Body have resided from the Beginning of the World ; and that a greater Knowledge than that of all Men living, is requisite to return a proper Answer to this Question.

And the Almighty seems to have propos'd much the like Question to *Job*, to convince him in the strongest manner of the Divine Glory and Greatness, and of his own Vileness and Nothingness, in the following Words : *Where wast thou when I laid the Foundations of the Earth ? Declare, if thou hast Understanding.* Ch. xxxviii. v. 4.

After the same Manner we find King *David* taking an Occasion to praise GOD, and to acknowledge his Works to be wonderful, from the Things that were unknown to him, but manifest to GOD alone. For after having confessed his own Ignorance, and extolled the infinite Knowledge of GOD in these Words of the CXXXIXth Psalm, ver. 6. *Knowledge is too wonderful for me ; it is high, I cannot attain unto it ;* he continues to say, in the 14th and following Verses, *I will praise thee, for I am fearfully and wonderfully made.* And, as if he did not thereby sufficiently acknowledge his own Ignorance, he adds, *Marvellous are thy Works, and that my Soul knoweth right well. My Substance* (otherwise my Bones or Strength) *was not hid from thee when I was made in secret, and curiously wrought in the lowest Parts of the Earth. Thine Eyes did see my Substance, yet being imperfect, and in thy Book all my Members were written, which in Continuance were fashioned, when as yet there was none of them.*

I should not have repeated these Things here, having had occasion to speak of them more than once already, were it not that we find much the same Expressions about the Existence of a human Body, as are analogous and uniform to the various Observations and Discoveries of the greatest Naturalists of our Age : And that an Infidel may be fully convinced thereof, let him only read what the great *Harvey* writes thereupon, *Exerc. 56. de Ord. Part. in Gen.*

We shall find in the aforesaid Treatise, that even in the second Month, the whole Frame of the little Embryo is of such a sort of inconsistent Substance, that it cannot be touched without it be laid in Water. Let then the Atheist consider, whether King *David* had not Reason to say, that *he was fearfully made ?* And would he not be frighted, in seeing how easily his precious Body, and the tender Limbs thereof may be squeeze'd to Pieces, or

turned

turned to a mishapen Creature, even by the Motion of the Mother's Bowels, and other Causes?

Secondly, The aforesaid Prophet says also, that he is *wonderfully made*; and after the same manner we hear the famous Philosopher *Harvey* expressing himself with Amazement, *Mirum dictu*, or, 'tis wonderful to say it, how far the *Embryo* or Fruit is in the fourth Month advanced in Bigness, being grown from the Length of an Inch to a Span.

Thirdly, The Psalmist of *Israel*, who names his first Beginning an *imperfect Substance*, could hardly express this with more emphatical Words than the abovementioned Author, when he tells us, that in the third Month the little Limbs begin to appear; but he adds, *Rudi tamen formâ*; that is, in a rough or irregular Form; insomuch that even the Muscles could not be then distinguished, tho' the Flesh, or greatest part of the Body be composed thereof. And when he proceeds to describe an *Embryo* four Months old, he says, that the Head of it was very large, the Face without Lips, Cheeks, or Nose: that the Mouth was likewise very large, and the Tongue visible therein, but the Eyes were small but without Eyelids; that the Flesh of the Forehead, which covered the whole Crown was not yet cartilaginous, far short of having acquired the Consistence of Bones. Now what Atheist can say, that the Holy Scriptures do not without Reason compare the Origin of all Men to an *imperfect Substance*? The rather, if we add thereto what Mr. *Dodart* says in the *History of the Academy of Sciences*, 1701, p. 26. *It is plain, that a Fœtus has very different Proportions from those of a grown Person; and that of the Limbs of a Man were made accordingly, they would be quite monstrous, and hardly pass for human.*

Lastly, These Expressions, *In thy Book all my Members were written, which in continuance were fashioned, when as yet there was none of them*, Pl. cxxxix. v. 16. do shew how well known to him that inspired the Holy Penmen, were these daily Changes of a *Fœtus*, after the same manner as they have been observed in our Ages by the aforesaid *Harvey* and *Malpighi*, and as they have been described in *Birds* by the latter from Day to Day.

To conclude then; Let an Atheist consider, from the few Passages here quoted, and from a great deal more that he will find in the abovementioned Authors, how much is unknown to him of his own Formation, and how exceedingly he is beholden to that great Wisdom and Power which expanded him from the little *Stamen* and Clew in which he was roll'd, first to an imperfect Substance, and afterwards to such a noble and well-contrived Body, without the least Knowledge or Concurrence on his own Part.

After these two Instances, we should pass on to something else, did we not think it might be of some use to those Philosophers who mean well, and do even read their Bibles with Reverence, to shew them a Mistake into which they fall, by depending more upon the Hypotheses they have learnt from their Masters, than upon true Experiments, and are accordingly persuaded, that many of those Things which the Holy Writ, to represent the Praise and Glory of the great Creator and Governour of the World, places
among

among those that are *unknown*, are now discover'd and thoroughly known in our Days; and consequently, that some at least of the Questions proposed by *Job*, which, by Reason of the slender Knowledge of the Naturalists who lived in those Ages, were really great Mysteries and Secrets then, are yet easily accounted for by the Moderns.

Thus the Question of *Elibu* to *Job*, ch. xxxvij. v. 17. *How thy Garments are worn, when he quieteth the Earth by the South Wind?* did not appear proper to a serious and learned Divine of my Acquaintance, because he thought, with most of the Philosophers of this Age, he was able to prove, that the Warmth of the Air (which, as several other great Commentators, he understood to be here meant) was only to be ascribed to the Operations and perpendicular Descent of the Sun-Beams.

But to convince all those who are of the same Opinion, as indeed it is the common Opinion of many Naturalists, of the great Wisdom of the Author of this Expression, and to let them see how much there remains still *unknown* in this Phænomenon, let them only take the Trouble of perusing what that eminent Inquirer into the Secrets of Nature, Dr. *Halley*, (as we find it in the Transactions of the *Royal Society*) writes very accurately and mathematically, about the Warmth which is produced by the Sun only in several Parts of the World; and how justly he says, that he knows no Reason why the Day, which is 24 Hours long under the North Pole, at the time when the Sun is in the Tropic of *Cancer*, should not be as hot there as that of the People who live under the Equinox, when the Sun is directly over their Heads? Forasmuch as by an exact Calculation, which he there makes, p. 333. he finds, that the Heat of each Day being reckon'd together, the Day under the *Pole* does as much exceed that of the *Equinox*, as 5 does 4.

They who please, may read the said Calculation demonstrated by him. It is sufficient for us to have proved, that principal Philosophers are likewise convinced, that a greater or lesser Heat is not to be imputed to a greater or lesser Height or Proximity of the Sun only.

And that the most famous Mathematicians, and greatest Genius's, have not been ashamed freely to acknowledge their Ignorance of the true Causes of this Heat, may appear from the *History of the French Academy of Sciences*, An. 1705. p. 49, and 50. where we meet with a circumstantial Account, that the People of *Montpellier* felt so violent a Heat on the 30 of *July*, that none of 'em ever remembered the like: The Air was as warm as if it came out of the Furnace of a Glass House, nor could they be cool any where but in their Cellars. All the Thermometers or Weather-Glasses which had been made by Mr. *Hubin*, burst in Pieces, and others represented such a Degree of Heat as was sufficient for melting Fat or Suet. Most of the Vines were set on fire that Day, which was never known before in that Country. That on the 30th of *August* the Heat was yet greater at *Paris*, and the Thermometer of Monsieur *Cassini* broke about Two o'Clock, tho' it had lasted 36 Years; an Argument that the Air of *Paris* had never been so heated in all that Time. After all which, the Historian goes on in these emphatical

Words:

Words: *Who would not have imagined that in the great Heat of this Summer, the Burning-Glass of the Palace Royal should have produced greater Effects than at any other Time? And yet it fell out quite contrary, and certainly (which is well worth observing) one would not have judged so, by any System of Philosophy.* Mons. *Homburg* did likewise observe, that the Sun-Beams being collected by the said Burning-Glass, exerted little or no extraordinary Strength, at the very Time when those which came directly down from the Sun, dispersed as they were, did in a Manner enflame the whole Region of Air.

Now I leave every Man to judge whether any plainer Confession is to be expected from such learned Men, from whence to conclude, that the just and perfect Cause of the Warmth of the Air is as yet unknown to us.

I shall not here repeat the Opinions of the said Mons. *Homburg*, which he himself does not pretend to be more than Conjectures. And the very Experiment which is there subjoin'd, and which seems to have some Analogy with this surprising Phenomenon (as it is there expressly named) is not even less wonderful hitherto. For it shews that a Chafing-Dish filled with burning Coals, and placed between the Focus and the Glass, in such a manner that the reflected Rays are obliged to pass thro' the Evaporations of those glowing Coals, the Action of the said Glass were notably weaken'd thereby.

They who are desirous to see more of the amazing Properties of the Augmentation and Diminution of the Force of this Burning-Glass, and such as the best Naturalists would be unable, perhaps, to deduce from his own Principles, if his Observations did not verify the same, may consult the above-mention'd Place.

We might produce several other Experiments in further Confirmation of what we have advanced. To be inform'd of one of them, we need only consult the 2d and 11th Proposition of the XXVith Chapter of the 2d Book of *Varenius's* Geography, where he says, That in the *Torrid Zone*, which lies between the Tropicks, the Seasons of the Year are entirely different from what we should expect from the Course of the Sun; so that in some Places 'tis *Winter* when the Sun is vertical, or just over their Heads, and *Summer*, when it is at its greatest Distance; for which Reasons that Author is forced to distinguish the Seasons of those Countries into *Calestes* and *Terrestres*; that is, such as are conformable to the Influences of the Heaven or Earth.

SECT. V. *It is unknown, whether the Earth or the Sun moves.*

IF now (passing by a great Number of Things that are still unknown) we proceed in the last Place to give a famous Instance of one more unknown Thing, namely, whether the Sun or the Earth moves, and consequently to which of them we owe the Days and Nights, and the Seasons of the Year: I doubt not but it may appear very surprising to many, and especially to those who without having taken the Pains, or had an Occasion experimentally to enquire into Astronomy themselves, do found the whole Structure of Natural Philosophy upon this or that Hypothesis; tho' otherwise the greatest Mathe-

Mathematicians are fully convinced, that altho' there has been perhaps no other Thing examined into with more Pains, Charge, and Application, in order to know the same with Certainty, yet nothing entirely positive can be advanced concerning it.

SECT. VI. *Such Ignorance proceeds, First, from the Disagreement of great Astronomers.*

Now to satisfy every unprejudiced Person of the Truth of what we have asserted, we shall endeavour to prove it, *First*, from the Disagreement of the greatest Inquirers into this Matter. Accordingly we find among the Ancients, that *Philolaus* held one side of the Question, and *Ptolemy* the other; and among the Moderns *Tycho Brahé* maintains that the Earth stands still, but *Kepler* that it moves, and both these were famous Astronomers. It may be the Reader will be surpris'd that I have not mentioned the Great *Copernicus*; but the Reason why I have omitted him is, because we find that he himself was convinced, that nothing could be certainly laid down concerning this matter in his Time, as we shall shew more fully by and by. Others again suppose the Diurnal Motion of the Earth about its own Axis but an Annual Motion of the Sun, who are therefore called *Semi-Tychonics*; and they likewise do thereby account for all the present known Phænomena, as well as *Copernicus* and *Tycho Brahé*.

To see this proved, we may consult Dr. *Gregory's* Astronomy, at the Eleventh Part of the First Book, together with many more Authors, who have with great Skill and Judgment shewn the Laws and Directions of the Motions whereby each of these three Hypotheses may be supported.

Since then these great Men, from whom only one might expect a Determination of these Disagreements, since they who have inquired into the Matter with so much more Care and Application than others, do still differ so much among themselves about the same, can any one believe that they would not long since have agreed in one and the same Opinion, if ever it had been fully and rightly proved? The rather, forasmuch as we find that they do not make the least Difficulty to depart from the Opinions of *Ptolemy*, concerning the Ways, or rather the Revolutions of *Venus* and *Mercury* (which he supposes to revolve about the Earth) as soon as ever the Experiments and Observations made by Telescopes had taught them, that these Planets moved only about the Sun, and by no means about the Earth; wherefore, as long as this Disagreement lasts between the greatest Mathematicians, we may be pretty sure that no Body has been able to see a solid Foundation of Truth in the Proofs produced by others; and consequently that other Arguments which only depend on the Observations of those, have not hitherto been able to prove any thing certain thereof.

SECT. VIII. *Secondly, Because great Astronomers do themselves own that they are uncertain about this Matter.*

Secondly, THIS may likewise be inferr'd from hence, that the most famous and most skilful Astronomers, after having employed so much Pains
in

in this Inquiry, do freely and honestly confess, that they are still entirely uncertain, concerning the Motion or Rest of the Earth; which Confession is yet stronger for this Purpose, than their Disagreement.

And to the end that this may not seem incredible to those who have a higher Opinion of these Mathematicians than they have of themselves, we will quote some of 'em, to witness the Truth of what is here advanced: Thus I remember, that having had the Honour to discourse with the Great Mr. *Huygens* about other Matters, and asking him whether he could affirm any thing, with Certainty, about the Earth's Motion; he was pleas'd to answer, *That it was his Opinion, that as long as we were upon this Earth, no Body could be able fully to prove the same.*

Thus likewise we see Sir *Isaac Newton*, tho' with Mr. *Huygens* he commonly supposes the Earth to move, yet he mentions the Matter with great Caution, and without advancing any thing positively; See *Princip. Philos.* p. 375. of the second Edition, where it being affirmed, among the Hypotheses, that the Center of the World is at rest, and not moved; this Reason is added, *this is allowed on of all Hands, whilst at the same time some make the Earth, others the Sun, to be at Rest in the Center of the World.* We likewise find in the fourth Phenomenon, this Expression; *Of the five Principal Planets, and (of the Sun about the Earth or) of the Earth about the Sun, the Times of the Revolution are, &c.* and in the fourth Proposition of the said third Book towards the End, we see these Words, *This Calculation (which is of some Moment) is founded on the Hypothesis of the Immobility of the Earth.*

And can any one speak out more plainly hereupon, than the famous and so highly esteemed Mathematician, *P. Herigonius*; who in his *Cursus Mathem. de Sphæra Mundi*, p. 53. uses these positive Words: *Whether the Earth is in the Centre of the Firmament, or out of it. Or, whether it is moved or not moved, cannot be proved by any Mathematical Demonstration.*

And that we may know that other great Men do likewise speak doubtfully of the Earth's Motion, we need only read the last Lines in p. 273. of Dr. *Gregory's Astronomy*; where speaking of the Parallax of the fixed Stars, with respect to the Earth's Way, he thus concludes: *For after this Manner they might put the Motion of the Earth out of doubt, which every one would own is well worth the while.* By which he shews how uncertain that Matter still is.

The Opinion of Mr. *de la Hire*, in the Preface to his *Astronomy*, is likewise declared upon this Matter; that Great Astronomer saying, *But after I had compos'd some Tables of the daily and yearly Motion of the Sun, or of the Earth, &c.* from whence it plainly appears, that he durst by no means determine the Matter.

Thus we find in the *Memoirs of the French Academy*, 1707. p. 14. That Mr. *Varignon* having said, that *Ricciolus* had given several Reasons for the Immobility of the Earth, and that *de Angelis* had returned an Answer to it, he the said Mr. *Varignon*, far from determining which of 'em was in the right, contented himself with declaring only, that he did not undertake to enquire into

their Arguments ; but suggested another Difficulty, which seems to render the *Earth's Motion* yet more uncertain.

If now down to this present Time, in which most of these Things have been written, one only solid Proof, to determine whether the Earth moved or stood still, had been known to these great Men ; can it be supposed that Persons of their Learning, most of whom from their Computations upon the Hypothesis of a *moving Earth*, would have spoken so doubtfully and uncertainly thereof.

SECT. VIII. *Thirdly, Because the Parallax from the Annual Motion is still uncertain.*

Thirdly, IT is true, that Mr. *Flamsteed* is of Opinion, that he is able to prove, from his Observations, a *Parallax* of the fixed Stars, and consequently that the Earth moves ; but with how little Certainty, may appear from the Place that we lately quoted out of Dr. *Gregory's Astronomy*, to which Mr. *Whiston* has replied in Defence of Mr. *Flamsteed* : But this whole Discovery seems to be but of little Use for this Purpose, chiefly from what we read of Mr. *Cassini*, the younger, in the *Transactions of the French Academy for the Year 1696.* to which Mr. *Whiston* answering in his *Prælect. Physic. Mathematicæ.* p. 202. (as much as he seems inclined to maintain the Certainty of the Earth's Motion from the abovemention'd Observations, for nothing certain can be concluded upon any other Principle) does confess, *that Mr. Flamsteed does not argue right in every thing, as the French have lately observed ; and that he often deduces the Parallax of the fix'd Stars from the Phenomena, that do by no means prove the same ; which in so great an Astronomer as he was, appeared very strange to him :* Concluding with the following Words, after he had said something which did not imply much Certainty ; *but this must be left to the farther Diligence and Wisdom of the Astronomers.* So that this Gentleman, who is otherwise wont to declare himself with very strong Expressions against those that maintain the Immobility of the Earth, does nevertheless in this Case, as it appears from his own Words, finally leave the Matter undetermined.

Now how little Hopes remain to find a *Parallax* of the fix'd Stars, whereupon to build with any Certainty, may be seen by Sect. XI. of the 3d Book of Dr. *Gregory's Astronomy*, and from the *Cosmotheoros* of Mr. *Huygens*, p. 134. &c. so likewise Sir *Isaac Newton* says, *Princip. Philos. Lib. 3. Sect. 14. That the Stars have no remarkable Parallax proceeding from the Annual Motion of the Earth.*

SECT. IX. *Nothing can be inferr'd from the Expressions used by great Astronomers, about the Earth's Motion.*

Now tho' the greatest Mathematicians of this Age are not ashamed freely to own their Uncertainty, as to the *Motion* or *Rest* of the *Earth* ; yet there is another Sort of Philosophers, who being but little skilled in Astronomy, or Mathematicks, do confidently and positively maintain, that the *Earth moves* ; because they cannot imagine that so many, and so great Men, should

should in their Writing and Calculations, suppose the same, if they were not fully assured thereof.

Now to convince them, that the Mathematicians themselves do not always give Credit to their own Hypotheses, there needs no more to be said, but that it is sufficient for Mathematicians, that they can most conveniently deduce from thence the hitherto known Phænomena, without considering, in the least, whether they be true or no: A great Proof thereof may be found in a certain kind of Preamble to the Book of the famous Copernicus, the whole of which were worthy to be transcribed by us, had it not been too large. It is there said, that it is not necessary that the Hypotheses should be even probable, and that it is enough if the Calculations may be thereby made to agree with the Experiments. And afterwards, and since various Hypotheses are often adapted to one Motion, (as in the Course of the Sun, an Eccentricity and a Motion about the Center) an Astronomer may chuse that which is most easily comprehended: A greater Probability may, perhaps, be required from a Philosopher, yet neither of them can be able to discover any thing with Certainty, unless God reveals it to them. Whereupon, finally, these emphatical Words follow: Let no Body, so far as it concerns an Hypothesis, expect any thing certain from Astronomy; since it won't afford any Thing like that, least by admitting for Truth that which is dress'd up for other Purposes, he should leave this Science with greater Folly than he engaged in it. I don't know whether any one could more strongly confirm what has been said before; and I think that the foregoing Objections are sufficiently answered hitherto, by referring our Readers to the Authors of these several Books.

Thus we find in the Text of Copernicus himself, *Lib. I. Cap. X. p. 20.* That this great Astronomer, instead of producing Reasons to support the Truth of his Hypothesis, contents himself with saying, *Which I think we ought to admit more readily, than to puzzle and confound our Minds with an infinite Number of Circles.*

After the same manner, says S. Stevin, in the 5th Proposition of the *Celestial Appearances*, with respect to a moving Earth; That it does not appear necessarily, that the Sun should be in the Center of the fix'd Stars, but that it is allowed to be so for good Reasons. And would you know his Reasons? They are the following: After having said, that it may be supposed, but, according to his Opinion, not fully proved; he concludes thus: *But it is more convenient to allow the Sun to be in the Center of the World, because other Phænomena may be more easily and rationally solv'd thereby.*

Thus we hear the famous Kepler speaking in his *Epitom. Astronom.* p. 448. and again 673. *When these Causes are understood, tho' they be not believed, but only supposed, the Use thereof will be very easy.*

But the same is very plainly made out by the *Transactions of the Royal French Academy*, 1709. where Mr. Cassini, after having spoken of the Uses, Properties, and Advantages of old and new Hypotheses with great Learning, (but without maintaining the Truth of any of 'em) describes very curious Planetary Machines, all of which are founded upon the Supposition of the Earth's Immobility. For which Reason likewise he places the same im-

moveably, in the middle of those Ellipses, which the Planets seem to revolve in, in the Space of several Years, with regard to the Earth itself; and he even marks the appearing Revolution of the Sun about the Earth with a pricked Circle. Now every Body knows, that altho' this great Astronomer does here use the Hypothesis of an immoveable Earth, yet he does by no means assert the Truth thereof; nay, he sometimes uses a different one.

From all which it appears, that these so highly esteemed Mathematicians do more consider the Conveniency than the Truth of their Hypotheses in very many Cases. But since some do pay such a blind Deference to their Science, that when they see an Hypothesis used by Men of a great Name, they take it only upon their Credit; therefore to convince these Gentlemen likewise, that we don't speak at random, when we affirm, that such a Mathematician does for the foregoing Reasons of Conveniency advance an Hypothesis, which is not only absolutely false, but even allowed to be so by himself, we shall present our Reader with a few Examples thereof.

Thus the Mathematicians do suppose imaginary Lines and Circles for the Construction of those so useful Tables of Sines and Tangents, &c. and in those of *Logarithms*, that all Numbers are the true ones; whereas among Hundreds of them, there be very few that are really so: For which Reason also, and that the Difference between true and false may be the less, their Way is to use such great Numbers.

So likewise Surveyors, or those that measure Land, tho' they find some Lines to be a little crooked, and sometimes go in and out in small Angles, yet they take them for strait ones; provided only that from the Supposition of such a known Falsity a greater Convenience results, and the Difference be not very considerable.

Who does not know, that making the Degrees of Latitude larger and larger in *Navigation*, is nothing but a meer Fiction, and only that one may with more Conveniency make good the real Decrease of each Degree of *Longitude*, though such useful and necessary Tables are calculated upon the same Foundation?

Though it be known to such as understand *Optics*, that Spherical Glasses never collect the Rays into a Point, (excepting in one or two Cases) as Glasses of some other Figures do: Yet how common a Thing is it in the making of Telescopes or Microscopes, to suppose the same, contrary to Truth; and the Demonstration of the *Practical* Part is founded thereupon, even by such as know that this is a manifest Falsity in the *Theory*?

What is more common than to suppose in *Statics*, that two Plumets fall down in strait Lines parallel to each other, whereas they would notwithstanding both meet at the Centre of the Earth?

In like manner, and upon the same Foundations, 'tis supposed by *Gunners*, and even by those famous Mathematicians that write upon the Art of throwing Bums, that their Balls by the Force of the Powder, and their own Gravity, do describe a Line, which they call a *Parabola*; whereas if they

they considered the Resistance of the Air, and other Causes aforementioned, they would know that the Properties thereof were very different.

In *Dialling*, we suppose the Center of the Earth, or rather of the Sun's Course, to be always at the Top of the Perpendicular Style (when the Shadow of it, as a *Nodus*, shews the Hour) wheresoever the Dial be plac'd upon the whole Earth, though every Body knows it to be contrary to the Truth.

Thus all the ancient and modern Astronomers have always taken it for a Foundation of their Calculations, that the true or apparent daily Motion of the Sun is in a Circle parallel or equally distant from the Equinoctial, notwithstanding that this Line, by the intermixing of the Sun's or Earth's Annual Course, comes nearer to a *Screw* or *Spiral Line*, than a Circle, as is well known to the Astronomers.

After having shewn all this in so many Branches of the Mathematicks, I don't think that a more express Demonstration will be required, to make appear, that altho' some of the chiefest among the Astronomers do suppose either the Motion or Rest of the Sun, and found their Calculations thereupon, yet this does not in the least shake either the one Hypothesis or the other: Since, provided the Mistakes be not of too great Importance, they frequently make use of Hypotheses for Convenience sake, which they themselves know to be false.

SECT. XI. *The Simplicity of an Hypothesis is not always an Argument of its Truth.*

THERE is yet one Argument from whence some People do conclude a little too hastily, that the Hypothesis of the Earth's Motion is true, namely, because it appears to them the *more simple* of all: And for farther Proof, say, that it is most becoming the Wisdom of the great Creator, to bring about the greatest Matters after the most *simple* Manner.

We shall not here enter into a large Discussion about the Weakness of this Characteristic; since no Body can know, when a Machine is shewed to him, whether it be the most simple or no, unless all the Views and Ends of him that invented it were at the same time disclosed to him, which none will presume to affirm concerning the Structure of the visible World: For upon this Foundation, those who maintain the Sun's or the Earth's Way to be circular, contrary to Experience, might justly alledge, that their Opinion had more Truth in it than that of those who maintained the same to move in an Ellipse or oval Figure: Forasmuch as beyond all Dispute the Figure of a Circle is more simple than that of an *Ellipsis*.

But to come a little closer; let such as maintain this, tell us what is the Reason why all Astronomers, at least all that I know, and among whom there are likewise many that zealously contend for the Earth's moving, and the Sun's standing still, as *Copernicus* himself, and since him *Kepler*, *Lansberg*, and in our time, the North-Hollander *Richard Rembransen van Nierop*; tho' all of them do in the *Theory*, or annual Course from East to West, maintain the Hypothesis of a moving Earth, (forasmuch as the Calculations are

much.

much more convenient according to them in this Case) yet in every Thing that belongs to the *Spharics*, or daily Revolution from East to West, they are wont to make their Figures and Calculations directly contrary to their own Notions, upon the Foot of a moving Sun and a resting Earth, tho' they commonly start the greatest Objections against this last.

Of what has been said, there is no farther Proof necessary, since this is apparent to every Body in almost all Figures that are used by them to this Purpose; in which they are even wont to express the *Parallels* in which the Sun daily moves, and to call them by that Name. It seems to me likewise to be particularly remarkable, that Mr. *Whiston* himself, who is otherwise so great a Champion for a moving Earth, does transcribe the Demonstration of the Manner after which Mr. *Cassini* has so ingeniously observed the *Parallax* of the *Planets*, into his *Prælect. Astron.* p. 75, &c. with so great respect from the *Act. Lips.* 1685. almost in the Works of Mr. *Blanchini*; notwithstanding that the same is formed upon the Hypothesis of a fixed Earth, and the daily Revolution of the fix'd Stars and Planets, shewing what he himself terms it, *The daily Revolution of Mars in a Circle*, and often using this Expression, *That Mars and the fix'd Stars are moved and carried round about by the Diurnal Motion.*

We might produce many more Instances here, to shew how little Account is made of all Hypotheses; but having dwelt so long upon this Matter already, we chuse rather to refer our Reader to the Preface of Mr. *de la Hire's Astronomy*; there is likewise something said about the same in our *Introduction*, Sect. XVI.

SECT. XII. *A Conclusion from the Whole, that neither the Sun's nor the Earth's Motion has ever been rightly proved.*

NOW to come to a Conclusion, from what has been hitherto said, of the Motion or Rest of the Earth.

I. Since the greatest Men do still differ upon this Point, and no Body has yet been ever able to produce a fix'd and solid Proof of the Truth on one Side or the other. (Sect. VI.)

II. Since such famous Mathematicians and principal Astronomers as *Huygens*, *Newton*, *la Hire*, *Varignon*, (to whom few will dare to compare themselves in the Knowledge of Astronomy, without being thought very presumptuous and conceited) and so many other have ingenuously confessed their Uncertainty in this Matter, tho' they are of the most modern, some of them being still alive, and all till lately; and consequently have had the best Opportunities that can be yet procured of examining into every Thing that has been discover'd concerning the same. (Sect. VIII.)

III. Since the hopes of finding out the *Parallax*, and Distance of the fix'd Stars from the Earth, are very small, by which otherwise the Matter might be determined after a good, if not the best Manner. (Sect. IX.)

IV. Since we cannot find any Demonstration of the Proof upon it, because very learned Men have indifferently made use of the one or the other Hypothesis; forasmuch as in almost all the Branches of Mathematicks, Hypotheses

potheses are used not to shew how the Thing is really in itself, but only in order to deduce from thence the known *Phænomena* with the greatest Convenience, and with the least sensible Difference ; so that even Things that are known to be entirely disagreeing with Truth, are frequently supposed, for the aforesaid Reasons, even by the greatest Men that treat of Mathematical Matters. (*Sett. X.*)

V. And lastly, since the same Mathematicians do one while make use of this Hypothesis, another while of that, according to their Convenience in present Cases, or for the Ease of their Calculations, or for the better Conception thereof ; or Description of them by Figures in the most plain and simple Manner. (*Sett. XI.*)

Let every Body consider with himself, whether he can be perswaded, that there will ever be discovered any solid or proper Proof, such as may be sufficient experimentally to convince Men, that the Motion or Rest of this Globe of the Earth is demonstrable, clearly and plainly, and to the Satisfaction of true Mathematicians : At least if any one should pretend to assert this, it would be the same Thing as if he should declare, that all those great and learned Astronomers above-named, have been either so ignorant as not to be able, or so malicious as not to be willing, to understand such a Proof ; which any Man who is just and reasonable, must think to be the greatest Absurdity.

F I N I S.





